CORPS OF ENGINEERS, U. S. ARMY

PLANS FOR IMPROVEMENT OF NAVIGATION CONDITIONS

AT

GREENVILLE BRIDGE, MISSISSIPPI RIVER

MODEL INVESTIGATION

TECHNICAL MEMORANDUM NO. 2-366

CONDUCTED FOR

VICKSBURG DISTRICT, CORPS OF ENGINEERS

BY

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

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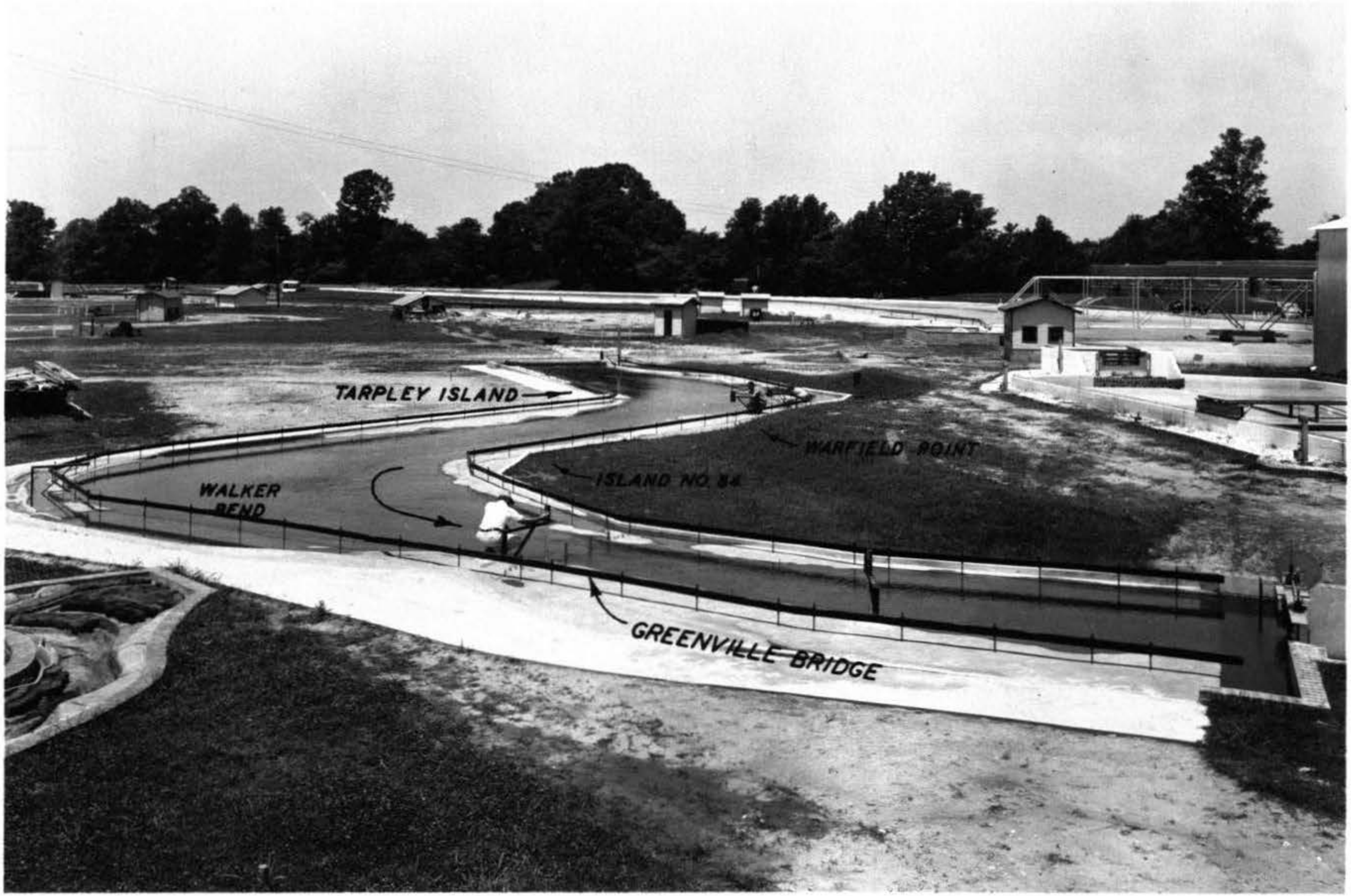

FRONTISPIECE. General view of the Greenville Bridge model, looking upstream

PREFACE

The model study of plans to improve navigation conditions on the Mississippi River in the vicinity of the Greenville Bridge at Greenville, Mississippi, was authorized by the President, Mississippi River Commission, in third indorsement to Vicksburg District, CE, letter dated 4 February 1949, subject: "Request for Model Study at Greenville Bridge." The tests were conducted by the Hydraulics Division of the Waterways Experiment Station during the period April 1949 to June 1951, under the supervision of Messrs. G. B. Fenwick, E. B. Lipscomb, and J. J. Franco, assisted by Messrs. W. L. McInnis, F. A. Pieper, W. E. Marsalis, and E. E. Moorhead. Active in liaison and advisory capacities were Messrs. R. A. Latimer, R. H. Haas, and A. B. Smith of the Mississippi River Commission, and Messrs. Key Woods and R. K. Stewart of the Vicksburg District.

Prior to undertaking the model study, personnel of the Waterways Experiment Station made an inspection trip to the problem area. The type of model to be constructed and the operational procedure to be followed were determined after conferences with representatives of the Mississippi River Commission and Vicksburg District. The prototype data necessary for construction and operation of the model and details of improvement plans to be tested were furnished by the Vicksburg District. Revisions to the original plans were made by the Mississippi River Commission and the Vicksburg District. Preliminary results of plans tested were forwarded to the Mississippi River Commission and the Vicksburg District at the conclusion of each test phase. The data presented in this memorandum supersede all preliminary results previously reported.

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SUMMARY

Tests to determine the effects of plans to improve troublesome navigation conditions on the Mississippi River in the vicinity of Greenville Bridge near Greenville, Mississippi, were conducted on a model built to a horizontal scale of 1:400 and a vertical scale of 1:150. The model was so constructed that it could be operated with either a fixed bed or a movable bed.

Results of the fixed-bed tests, which were conducted with February-March 1949 channel conditions installed, indicated that: (a) none of the proposed left-bank dikes downstream from Warfield Point would effect the desired improvement in flow conditions in the Greenville Bridge reach; and (b) an eastward realignment of the left bank and channel upstream from Warfield Point together with a westward realignment of the right bank and channel between Warfield Point and Walker Bend would reduce velocities in the vicinity of the Greenville Bridge and tend to provide more satisfactory navigation conditions in this reach.

Results of the movable-bed tests, conducted with the model bed molded initially to the March-April 1950 channel conditions, tended to confirm indications obtained in the fixed-bed tests. In general, results of the movable-bed tests indicated that: (a) probable future channel developments in the Greenville Bridge reach for a period of several years, without installation of improvement works, would not tend to deflect flow to the right bank at a point farther upstream in Walker Bend; (b) installation of a dike on the left bank just upstream from Island No. 84 and a supplementary dike on the right bank at Tarpley Island would not effect

the desired channel development along the right bank leading into Walker Bend; and (c) dredging and maintenance of a directive channel to force flow from the right bank at Tarpley Island to the left bank, and an eastward realignment of the left bank and channel above Warfield Point without any initial change in alignment of the right bank and channel between Warfield Point and Walker Bend, would not produce the desired improvement in flow in the Greenville Bridge reach.

PLANS FOR IMPROVEMENT OF NAVIGATION CONDITIONS AT GREENVILLE BRIDGE, MISSISSIPPI RIVER

Model Investigation

PART I: THE PROBLEM AND ITS LOCALE

1. The Greenville Bridge is located on the Mississippi River approximately 12 miles downstream from Greenville, Mississippi (see vicinity map, plate 1). It was completed during the latter part of 1940 and comprises three river spans and extensive land approaches. The river spans have a total length of 2121 ft with the center or navigation span having a clear width of 800 ft; clearance above the 1927 high-water plane is 65 ft.

2. The Mississippi River in the immediate vicinity of the bridge is narrow and restricted in area in comparison with widths and areas upstream and downstream. The channel at the bridge averages 2400 ft in width and 60 ft in depth at bankfull flow. The restriction in channel cross section causes the river flow to be exceedingly turbulent and currents to be very strong in the upstream approach to the bridge. Since completion of the structure, stages on the Greenville Bridge gage (zero elevation, 74.92*) have varied from 8.3 ft in November 1940 to 53.8 ft in April 1945; discharges have varied from 105,000 cfs in November 1940 to 1,911,000 cfs in April 1945.

3. High velocities have long been observed in the Greenville Bridge reach, but changes in channel alignment above the bridge in recent years

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* All elevations are in feet above mean sea level.

have increased the seriousness of the navigation problem in this vicinity. In 1942, the main channel followed the Arkansas shore from just above Vaucluse revetment to the bridge, thus giving a straight approach of several miles above the bridge. The river current, at that time, prevented the bar along the Mississippi shore from building out into the navigation channel. In about 1942, the channel location through Leland Cutoff began shifting, thus affecting the channel alignment downstream. By 1949 the channel thalweg at the upper end of Island No. 84 had migrated from the right (Arkansas) bank to the left bank. During this period of channel shifting, the upper face of the bar at Island No. 84 was washed away and a chute developed along the Mississippi shore back of the bar. Flow through the chute converged with the main channel flow immediately above the bridge, resulting in the formation of a large eddy with cross currents and boils. The main channel flow across and along the bar at Island No. 84 shifted the bar downstream and further restricted the channel above the bridge, thus making conditions unfavorable for towboat navigation during certain river stages. The towboat "Natchez" struck one of the bridge piers in March 1948 and capsized with considerable loss of life. This tragedy focused attention on the navigation problems of the reach and intensified efforts to devise remedial measures.

4. All plans proposed for improving navigation conditions through the reach were concerned with forcing the thalweg of the river to resume its former course along the right bank just above and through Walker Bend in order to re-establish the long straight approach above the bridge that existed in 1942. Such plans fell into two basic categories: (a) those involving construction of dikes along the left bank below Warfield Point

to deflect the flow toward the right bank in Walker Bend; and (b) those involving the eastward realignment of the left bank and the thalweg in the vicinity of and above Warfield Point to accomplish the same end through curvature of the channel upstream from Walker Bend.

5. It was readily apparent that there was no definite assurance that such plans, all of which would require extensive and costly construction and/or dredging operations, would accomplish the desired results. It was decided, therefore, to investigate the effectiveness of the plans by means of a model study.

PART II: THE MODEL

6. The model was constructed so that the channel bed could be fixed in concrete or molded in a movable material in accordance with the requirements of the tests. The basic criteria for design of a model of this type are that it accurately reproduce corresponding prototype stage-discharge relationships when operating as a fixed-bed model, and that it correctly simulate bed movement and changes in channel configuration when operating as a movable-bed model. Considering these criteria, the linear-scale ratios selected for the model were 1:400 horizontally and 1:150 vertically.

7. The model reproduced approximately 14.1 miles of the Mississippi River from upper Tarpley Cutoff to Refuge Landing (model limits are shown on plate 1). The frontispiece is a general view of the model. A minimum of overbank area was included since the maximum flow to be studied was about a bankfull stage. In general, the overbank was molded to the 1930 topographic survey but, where available, overbank detail was taken from the 1947 and 1949 hydrographic surveys. Except for minor revisions, which will be discussed in their proper sequence in the testing procedure, the model channel for the fixed-bed tests was molded to the February-March 1949 hydrographic survey between ranges 8 to 76 and to the August 1947 hydrographic survey between ranges 1 to 7 (locations of ranges may be seen on plate 3). The March-April 1950 survey was used to mold the channel for the movable-bed tests prior to installation of the proposed improvement plans.

8. The model was 186 ft long with a maximum width of 32 ft. Its

effective area was 4,952 sq ft, equivalent to approximately 28 sq miles of prototype area. For both fixed-bed and movable-bed tests, channels were molded to sheet-metal templets. Templets and all surface details were located on the model by means of a modified polyconic grid system set up during construction.

9. Model appurtenances were of conventional types and require no detailed description. Inflows were measured by venturi meters and a V-notch weir. Water-surface elevations were measured by means of fixed and portable point gages. Tailwater elevations were controlled by an adjustable tailgate. Current velocities were measured by means of a miniature propeller-type current meter. A granular coal graded to grain-size specifications was used for the movable-bed material.

10. Operation of the model was conducted in two separate phases: (a) fixed-bed tests with the entire model molded in concrete and flows at constant discharge; and (b) movable-bed tests with the overbank areas molded in concrete, the channel molded in granular coal, and flows at varying discharges. The two phases required separate model-prototype verifications and different operating procedures, and will therefore be considered separately in the following discussions.

PART III: TESTS ON FIXED-BED MODEL

11. At the time the model study was undertaken information was desired as soon as practicable as to the probable effects of the proposed improvement plans for alleviating the troublesome conditions existing in the vicinity of Greenville Bridge. Therefore, the fixed-bed (first) phase of the investigation was concerned primarily with determining the effects of proposed improvement plans on water-surface profiles, current directions, and velocities. Before the fixed-bed tests were undertaken, it was necessary to adjust the model so that stage-discharge relationships agreed closely with corresponding prototype relationships.

Model Adjustment

12. Adjustment of the model preparatory to conducting the fixed-bed tests was accomplished by adjusting the channel roughness to provide an accurate reproduction of the prototype water-surface profile of 11 March 1949 (approximately bankfull). In accomplishing this, the proper discharge was introduced into the model, the tailwater elevation was held to the corresponding prototype elevation for that flow, and the channel roughness was adjusted by trial and error until water-surface elevations at all model gaging stations corresponded to prototype elevations for the flow used. During this adjustment it was found expedient to change the discharge scale from the theoretical value of 1:734,800 to 1:493,300 in order to minimize the extent of model roughness required to obtain an accurate reproduction of prototype stages.

13. The water-surface profile obtained for the 35-ft stage

(bankfull flow) in the fixed-bed adjustment is shown on plate 2, together with the corresponding prototype water-surface profile for 11 March 1949. Each profile represents averages of gage readings taken on the right and left banks. The maximum variation between the two profiles is about 0.6 ft.

Testing Procedure

14. All fixed-bed tests were conducted with a constant discharge that represented the 35-ft stage or approximately bankfull flow for the Greenville Bridge reach. Tailwater elevations were controlled by using the tailgate settings obtained in the adjustment test.

Tests and Results

Base test

15. The purpose of this test was to obtain data for use as a basis of comparison in determining the effects of subsequent tests of proposed improvement plans. The base test for the fixed-bed phase was conducted with the model bed molded in concrete to prototype conditions of February-March 1949 (see plate 3).

16. Water-surface elevations were measured at the six model gages shown on plate 3, and the resulting water-surface profile is shown on plate 4. Surface-current directions and velocities obtained during the base test are presented on plate 5. It will be noted that maximum velocities of about 10 to 11 ft per sec were measured upstream from the Greenville Bridge, while maximum velocities of 13 to 14 ft per sec were obtained in the immediate vicinity of the bridge.

Test 1

17. The first improvement plan tested in the fixed-bed phase (see plates 6 and 7 and photograph 1) consisted of a dike and borrow pit on the left bank downstream from Warfield Point. The dike was 5000 ft long with side slopes of 1 on 4, and its crest set to an elevation 39 ft above the low-water plane or approximately top-bank elevation (126 ft msl). The borrow cut was 600 ft wide and was excavated in the channel offshore from the dike to simulate the dredged area from which fill material would be obtained for the dike. The bottom of the cut was set to an elevation of 40 ft msl or 47 ft below the low-water plane. The model channel configuration for this test (plate 6) was the same as for the base test, except for some revision in the vicinity of the proposed structure to correspond to the more recent prototype survey of 10-15 March 1949.

18. Water-surface elevations observed during the test are plotted on plate 4. Comparison of the profile obtained in test 1 with that obtained in the base test shows that the dike increased water-surface elevations a maximum of about 1.2 ft in the reach upstream from Warfield Point.

19. Surface-current directions and velocities measured during the test are presented on plate 7. In addition, photograph 1 shows current directions in the vicinity of the dike. Comparison of plates 5 and 7 shows that installation of the dike in test 1 increased velocities in the vicinity of the dike about 4 or 5 ft per sec over those obtained in the base test; however, velocities at the Greenville Bridge were not appreciably affected.

Test 2

20. The purpose of test 2 was to determine the effect of extending

downstream the left-bank dike and borrow cut studied in test 1. As shown on plates 8 and 9 and photograph 2, the dike was lengthened to 9100 ft with a corresponding lengthening of the borrow cut along the offshore side. The crest elevation and side slopes of the dike and bottom elevation and width of the cut were the same as in test 1. The model channel configuration for this test (plate 8) was the same as for test 1, except that the midstream bar upstream from Warfield Point was revised to the more recent prototype survey of 10-15 March 1949.

21. Water-surface elevations observed during the test are shown on plate 4. Extension of the 5000-ft dike to 9100 ft increased water-surface elevations over those obtained in test 1 about 1.1 ft at the Warfield Point gage (mile 528.8) and about 0.4 ft at the upper end of the model at mile 533.8.

22. Surface-current directions and velocities measured during test 2 are presented on plate 9. Photograph 2 shows current directions in the vicinity of the dike. Comparison of plates 7 and 9 shows that extension of the dike to 9100 ft did not appreciably change velocities in the main channel offshore of the dike; however, velocities just off the downstream end of the dike were increased some 3 or 4 ft per sec. Velocities in the navigation channel at the Greenville Bridge were decreased slightly in test 2, probably because the longer dike was slightly more effective in directing flow toward the right bank in the bend just above the bridge.

Test 3

23. The purpose of test 3 was to determine the effect of deepening and widening the channel along the offshore side of the dike used in test 2

to provide a total enlargement approximately equal to the part of the original channel rendered ineffective by the dike. The dike and revised channel configuration for test 3 are shown on plate 10; the remainder of the model bed was the same as in test 2.

24. Water-surface elevations measured during the test are shown on plate 4. It will be noted that in test 3 water-surface elevations in the reach upstream from the dike were lowered considerably below those measured in test 2, with a maximum lowering of about 2.0 ft at Warfield Point. However, the water-surface elevation at mile 524.5 (gage C) in test 3 was increased about 0.5 over the elevation measured at this point in test 2.

25. Surface-current directions and velocities measured during the test are presented on plate 11. Photograph 3 shows current directions in the vicinity of the dike. Comparison of plates 9 and 11 shows that enlargement of the channel in the vicinity of the dike in test 3 reduced the velocities measured in this area considerably below those measured in test 2; however, velocities in the vicinity of the Greenville Bridge were not appreciably affected. Current directions in test 3 did not differ appreciably from those observed in test 2.

Test 4

26. Test 4 was conducted for the purpose of determining the effects of realigning the left bank upstream from Warfield Point. It was thought that an eastward realignment of this bank would tend to direct the flow line toward the right bank at a point farther upstream in Walker Bend than that followed by the flow in 1949. As shown on plates 12 and 13, the left bank of the model between Warfield Point and model range 64 was realigned eastward about 600 to 800 ft with a slope of 1.0 vertical

to 4.0 horizontal. In addition, the channel just offshore from the realigned bank was excavated to a depth of about 49 ft below the low-water plane. Also, the model channel between ranges 43 to 29 inclusive was revised to conform approximately to February-March 1949 conditions. The remainder of the model bed was the same as in test 3.

27. Water-surface elevations measured during the test are shown on plate 4. It will be noted that test 4 water-surface elevations were higher at mile 524.5 (gage C) and mile 528.8 (Warfield Point) than those obtained in the base test; however, the water-surface elevation at mile 533.8 (gage A) was about 0.2 ft lower in test 4 than in the base test.

28. Surface-current directions and velocities measured during the test are presented on plate 13. Comparison of plates 5 and 13 shows that the eastward realignment of the left bank upstream from Warfield Point in test 4 decreased velocities in this vicinity about 2 or 3 ft per sec below those obtained in the base test; velocities downstream from Warfield Point were not appreciably affected by the realignment of the left bank. Observations of current directions in test 4 indicated that, although there was a larger concentration of flow at Warfield Point as a result of the realigned bank just upstream, the tendency for a crossing to the right bank to develop just below Warfield Point probably would be slight.

Test 5

29. Test 5 was conducted for the purpose of determining the effects of decreasing the cross-sectional area opposite the realigned left bank used in test 4 and realigning the right bank and channel between Warfield Point and Walker Bend. As shown on plate 14, the center bar opposite the realigned bank upstream from Warfield Point was enlarged and

extended eastward in test 5 in order to effect an increase in velocities at Warfield Point. The right bank opposite and downstream from Warfield Point was realigned westward about 1000 ft between model ranges 47 to 35. In addition, a channel with depths of 32 to 34 ft below the low-water plane and a minimum width of approximately 1000 ft was installed along the realigned right bank and connected to the left-bank channel at Warfield Point and the right-bank channel in Walker Bend. The remainder of the model bed was the same as in test 4.

30. Water-surface elevations obtained during the test are shown on plate 4. Comparison of the profile obtained in test 5 with the profile obtained in the base test shows that widening and deepening of the channel between Warfield Point and Walker Bend lowered water-surface elevations a maximum of about 0.9 ft at Warfield Point.

31. Surface-current directions obtained during the test are shown on plate 15. Comparison of plates 5 and 15 shows that, in general, flow conditions observed in the base test just upstream from the Greenville Bridge were not appreciably affected by revisions made for test 5; accordingly, velocity measurements were not taken during this test.

Test 6

32. The final fixed-bed test was conducted for the purpose of determining the effects of further modifications of the plan used in test 5. The channel configuration for test 6 is shown on plate 16. It will be noted that the bars opposite the realigned banks were enlarged considerably and increased in height in order further to constrict the main channel. The left-bank channel downstream from Warfield Point was filled to a height of about 12 ft above the low-water plane to provide one large

continuous bar along the left bank from Warfield Point to just above the Greenville Bridge.

33. Water-surface elevations obtained during test 6 are presented on plate 4. Comparison of the profile obtained in test 6 with the profile obtained in test 5 shows that enlargement of the bars and constriction of the main channel greatly increased water-surface elevations upstream from mile 524.5. An increase in water-surface elevations of about 4.0 ft above the profile for test 5 was measured in test 6 at Warfield Point, and an increase of about 5.7 ft was measured at mile 533.8.

34. Surface-current directions and velocity measurements obtained during the test are shown on plate 17. Photographs 4 and 5 show current directions in the model. Comparison of current directions obtained in test 5 (plate 15) with those obtained in test 6 (plate 17) reveals that flow entered Walker Bend farther upstream in the latter test thus tending to improve conditions at the Greenville Bridge. Velocities measured at the Greenville Bridge in test 6 were considerably lower than velocities measured in previous tests and did not exceed about 7 or 8 ft per sec.

PART IV: TESTS ON MOVABLE-BED MODEL

35. Upon completion of the fixed-bed tests described in part III, the concrete channel of the model between miles 531.9 AHP and 521.1 AHP (plate 1) was replaced with a movable bed of granular coal, and verification of the movable bed was initiated preparatory to conducting tests of improvement plans. The purpose of the movable-bed study was to develop the most effective plan of improvement and to determine its effect on the channel configuration.

Movable-bed Verification

36. The granular coal bed material had a specific gravity of 1.28. Material passing an 8-mesh screen and retained on a 28-mesh screen was used in the initial trial-verification tests. It was washed to remove foreign matter and coal dust.

37. Verification of a movable-bed model is essentially a trial-and-error procedure with empirical values assigned to various scale relationships. Prior to each trial-verification test for this study, the movable bed was molded to conform to the June-September 1947 prototype hydrographic survey (see plate 18). A time scale of six hours in the model to one year in the prototype was used at the beginning of model operation. Inflows based upon a step hydrograph plotted from recorded prototype stages for the period June 1947 to August 1949 were introduced in the model. This period was chosen because it was the latest for which complete hydrographic surveys were available. The hydrograph used is shown on plate 19. The model inflow discharges were adjusted to produce

the proper stages at the Warfield Point gage which was used as the upper control gage. Tailwater elevations at the Greenville Bridge gage, the lower control gage, were held to values computed from recorded prototype stage data. Bed material was introduced just above the movable-bed section to simulate material moved into that area from the next upstream reach. Prototype dredging was simulated by manual removal and redeposition of material in accordance with furnished dredging plans and surveys. Small gravel was used to simulate prototype revetment extending offshore past the concrete model banks. Water-surface elevations were taken at all gaging points for each successive stage of the step hydrograph. After completion of each trial-verification test, the movable bed was cross-sectioned and the results plotted for comparison with the August 1949 prototype hydrographic survey and with preceding tests. Results of the comparison were analyzed and adjustments made in the rate of introducing bed material, grain size of bed material, time scale, discharge scale, slope of water-surface profiles, and slope of bed profile. This trial-and-error procedure was continued until a satisfactory verification of the movable bed was obtained.

38. During the trial-verification tests, changes were made in a number of the variable scale relationships. The granular coal bed material was resized to pass through a 4-mesh screen and be retained on a 30-mesh screen. This resulted in a mean grain diameter of about 1.3 mm. The time scale used for the final successful verification test, and for all succeeding tests, was 15 model hours equal to one prototype year. A late prototype hydrographic survey was made in April 1950, and the verification period for the final verification test was extended from

August 1949 to April 1950. A supplementary slope of 0.000273 was added to the bed profile and to water-surface profiles for all stages.

39. Plate 20 shows the prototype channel configuration at the end of the verification period; plate 21 shows the model channel configuration obtained for the same period. Comparison of the two plates shows that the tendencies for channel development and bar building in the model were quite similar to those in the prototype; accordingly, it was concluded that the verification test provided a satisfactory reproduction of the prototype changes that occurred during the verification period.

Testing Procedure

40. After a satisfactory verification of the model had been attained, tests were conducted of existing conditions and of several proposed improvement plans. Prior to the beginning of operation of each of the tests hereinafter described, the movable bed of the model was molded to conform to the prototype survey of March-April 1950 (plate 20), and the improvement plan to be studied was installed in the model.

41. Each of the tests consisted of a series of "runs," each run consisting of one reproduction in the model of the one-year hydrograph shown on plate 22. This synthetic hydrograph was based on an average of prototype stage data recorded during the period 1940-1949. As has been stated previously, the time scale used in the movable-bed test was 15 model hours to one prototype year.

42. The settings of the various stages of the model hydrograph used for the movable-bed tests were based upon discharges and tailgate elevations established in adjustment runs immediately after completion of

the verification test. Total model inflow for each stage was controlled by holding the Warfield Point gage to the proper elevation for that stage; similarly, tailwater elevations were controlled by holding the Greenville Bridge gage to the proper elevations for the stages being reproduced.

43. Bed material was introduced into the upper end of the model during each run of the base test in simulation of material being moved downstream in the prototype. The amount of bed material introduced into the model during each run of tests of improvement plans was based upon the rate of introduction established in the base test or test of existing conditions.

Tests and Results

Base test

44. The purpose of this test was twofold: first, to determine the probable ultimate channel configuration that could be expected without installation of any improvement works; and second, to provide a basis of comparison for determining the effects of improvement plans tested. The base test consisted of three runs or a total operating time on the model of 45 hours.

45. Plate 23 shows channel bed configurations at the end of the base test. Comparison of plate 23 with plate 20, showing the channel configuration at the start of the test, indicates that no changes would occur in this reach, in the near future, of sufficient magnitude to induce flow to enter farther upstream in Walker Bend. Photographs 6 and 7 show channel configurations at the end of run 1 (15-hours operation);

photographs 8 and 9 show channel configurations at the end of the test.

46. Tables 1 and 2 list velocity observations made on model sounding ranges 12 and 14 during the base test. Inspection of these two tables shows that during run 2, maximum velocities of 8 to 10 ft per sec were measured on the 30-ft river stage at range 12 just downstream from the bridge while maximum velocities of 10 and 11 ft per sec were measured at range 14 just upstream from the bridge on the same stage.

Test 7

47. The plan investigated in test 7 was based on the development of a channel along the right bank at Tarpley Island which would cross over to the left bank in the vicinity of Warfield Point. The plan included an articulated concrete revetment to be placed in the prototype along the left bank from Warfield Point to Island No. 84. In addition, a low sand dike covered with stone would be constructed so as to extend from the left bank at the head of Island No. 84 to direct the current away from the bank and into Walker Bend. The dike was 3750 ft long with crest elevation 15 ft above the low-water plane, a crown width of 20 ft, and side slopes of 1 on 3. In the model it was constructed from coal bed material and left unprotected at the start of the test. However, it soon became necessary to protect the dike with a layer of pea gravel. Photograph 10 shows the dike as constructed in the model and the channel configuration from above Warfield Point to Walker Bend before the start of the test. Plate 24 also shows the channel configuration and plan of improvement as installed in the model. Three runs were conducted in test 7 for a total operating time of 45 hours.

48. Photograph 11 shows the channel configurations at the end of

run 1; photographs 12 and 13 depict surface-current directions in the model on the 35-ft (crest) stage and 5-ft (falling) stage of run 1. Inspection of these photographs shows that the proposed dike at Island No. 84 was not effective in diverting flow from the left bank toward the right bank in Walker Bend.

49. At the end of run 2 representatives of the Vicksburg District requested that a supplementary dike be installed in the model just upstream from Leland Neck in an attempt to effect a crossing to the left bank above Warfield Point. It was thought that the diversion of more flow to the left bank above Warfield Point rather than just downstream of the point might increase the effectiveness of the dike at the head of Island No. 84. Therefore, a dike 2500 ft long was installed in the model extending out from the right bank just above model range 65 (see plate 25 and photograph 14). The dike had side and end slopes of 1 on 3, a crown width of 20 ft, and a crest elevation 25 ft above the low-water plane. It was constructed of coal and covered with a layer of pea gravel to prevent severe scour. After the peak flows of run 3 a tendency was observed for a crossing to develop from the right bank at Tarpley Island to the left bank, but it appeared to be too far downstream to be most effective. Representatives of the Vicksburg District requested that a pilot cut be dredged just upstream from the supplementary dike at Tarpley Island to assist in directing flow to the left bank above the entrance to Greenville Harbor. As shown on plate 25 and photograph 15, a pilot cut 7000 ft long was dredged from Tarpley Island to the left bank upstream from and paralleling the supplementary dike during the 15-ft falling stage of run 3. The cut was dredged to a depth of about 19 ft

below the low-water plane and had a bottom width of approximately 200 ft.

50. The channel configuration obtained at the end of the test is shown on plate 25. Comparison of plate 25 with plate 24, which shows the channel configuration at the start of the test, discloses that the main channel upstream from Warfield Point was realigned eastward about 3000 to 4000 ft. Also, the channel alignment entering Walker Bend was shifted upstream but not as far as was considered necessary to alleviate troublesome conditions at the Greenville Bridge. Photographs 15 and 16 depict the channel configurations at the end of the test.

51. Current velocities measured at certain critical points in the main channel are presented in tables 3 to 6 inclusive. During run 2 velocities of 8 and 9 ft per sec were measured at the 35-ft stage just below the Greenville Bridge on range 12 (table 3), while velocities of 9 and 10 ft per sec were measured at the same stage just above the bridge on range 14 (table 4). No appreciable changes in velocities were noted on range 14 from the start to the end of the test. Velocities of 8 and 9 ft per sec were measured during run 1 on range 30 (table 5) near the dike at Island No. 84, while velocities of 7 and 8 ft per sec were measured during run 3 on range 63 (table 6) just downstream from the supplementary dike.

Test 8

52. The final plan tested in the movable-bed phase of the model study is shown on plate 26 and photograph 17. This plan consisted of a realignment of the entrance channel to direct flow from the right bank at Tarpley Island to the left bank above Warfield Point and the shifting eastward of the bank upstream from Warfield Point to the approximate

realignment used in fixed-bed tests 4 to 6. Entrance conditions were altered to provide a directive channel with a bottom width of 1000 ft, side slopes of 1 on 2 (model), and a minimum depth of 24 ft below the low-water plane. This channel extended from the right bank at about range 72 to the left bank at about range 62 (plate 26). The gravel apron at the upstream model entrance was extended to about range 67 in order to completely stabilize the channel in this area. The left bank of the model between Warfield Point and model range 64 was realigned eastward about 600 to 800 ft with an approximate slope of 1.0 vertical to 4.0 horizontal. It was assumed that material from the channel and bank realignments would be redeposited on the bars opposite the points of removal. Material from the directive channel installed at the model entrance was spoiled along the right bank below the cut. Material removed from the left bank above Warfield Point was spoiled on the adjacent center bar. The remainder of the model bed downstream from Warfield Point was molded to the March-April 1950 prototype hydrographic survey. Four runs were conducted in test 8 for a total operating time of 60 hours.

53. The channel configuration obtained at the end of run 3 is shown on plate 27. Comparison of plate 27 with plate 26, showing the channel configuration at the start of test 8, shows little change in the reach upstream from Warfield Point; however, some fill occurred along the left bank downstream from Warfield Point with some deepening along the right-bank bar entering Walker Bend. Visual observations indicated that the bed was not completely stabilized and the model was operated for one additional run of 15 hours in order to allow the full effects of the major realignment of the bank and channel upstream from Warfield Point to

be developed. The channel configuration at the end of run 4 is shown on plate 28. Comparison of plate 28 with plate 27 shows that the bar along the left bank at Island 84 built out toward the right bank, and the crossing entering Walker Bend was not shifted farther upstream by this plan.

54. Photographs 18 to 23 show current directions and channel configurations during and at the end of the test.

55. Current velocities measured at certain critical points in the main channel are presented in tables 7 to 9 inclusive. Velocities of 8 to 10 ft per sec were measured at the 35-ft stage just below the Greenville Bridge on range 12 (table 7) while velocities of 10 to 12 ft per sec were measured at the same stage just above the bridge on range 14 (table 8). Maximum velocities of 10 and 11 ft per sec were measured on range 53 just upstream from the entrance to Greenville Harbor (table 9).

PART V: DISCUSSION OF RESULTS

56. The fixed-bed phase of the study of plans to alleviate troublesome navigation conditions in the vicinity of the Greenville Bridge was successful in accomplishing the specific purpose for which it was undertaken, i.e., quick determination of effects of proposed improvement plans on water-surface profiles, current directions, and velocities. The results of the fixed-bed tests may be accepted as accurate indications of the stages, velocities, and current directions that will occur in the river under similar discharge and channel-configuration conditions.

57. The movable-bed phase of the study was not considered entirely successful in that a satisfactory plan of improvement was not developed in the model. However, a satisfactory verification of the movable bed was obtained and reliable qualitative indications provided as to trends in channel configurations and velocities to be expected for the improvement plans tested.

58. The principal conclusions drawn from analysis of the data obtained in the fixed-bed studies are:

- a. Installation of left-bank dikes between Warfield Point and Island No. 84 would not appreciably shift flow to the right bank far enough upstream in Walker Bend to improve navigation conditions at the Greenville Bridge. Current velocities along the offshore face of a dike constructed in this area probably would be high enough to necessitate complete protection from scour for the dike.

- b. An eastward realignment of the left bank and channel upstream from Warfield Point, together with a westward realignment of the right bank and channel between Warfield Point and Walker Bend, would cause flow to enter Walker Bend farther upstream, would lower velocities and improve flow conditions at Greenville Bridge.

59. The principal conclusions derived from analysis of the data obtained in the movable-bed studies are:

a. Probable channel developments in the Greenville Bridge reach for a period of several years, based on the channel configurations shown by the March-April 1950 prototype survey and the omission of any improvement works, would not tend to shift flow farther upstream in Walker Bend.

b. Installation of a 3750-ft dike on the left bank between Warfield Point and Island No. 84 and a 2500-ft supplementary dike on the right bank at Tarpley Island would not effect the changes in channel configuration required to cause flow to enter Walker Bend farther upstream. However, installation of a supplementary dike on the right bank at Tarpley Island would shift the main channel in this area from the left bank eastward about 3000 to 4000 ft.

c. Installation of a 1000-ft-wide directive channel to force flow to cross over from Tarpley Island to the left bank, and a 600-ft to 800-ft eastward realignment of the left bank and channel upstream from Warfield Point (without any initial changes in channel configurations downstream) would not effect the channel development necessary for flow to enter Walker Bend farther upstream.

60. Although this model study did not provide a positive solution to the problem at Greenville Bridge, it did prove the validity of the assumption of the design engineers that an effective means of alleviating the problem would be to force the thalweg into its old course along the right bank at Walker Bend, thus re-establishing a long straight approach to the bridge. The model study also afforded negative benefits in that it indicated the ineffectiveness of the proposed improvement plans, thereby precluding the construction of expensive, ineffectual works in the prototype.

PART VI: EPILOGUE

61. No major improvement measures have been undertaken in the prototype since completion of the model investigation in June 1951, but, as a matter of interest, a brief review of late developments in this reach of river is presented in the following paragraphs.

62. Recent discussions with representatives of the Mississippi River Commission and Vicksburg District indicate that no particular difficulty, from a navigational viewpoint, is now being experienced in the vicinity of the Greenville Bridge. Velocities appear to be slightly less than those observed three or four years ago, and navigating conditions have improved considerably.

63. Comparison of a prototype survey dated March-April 1949 with the latest available prototype survey dated January-February 1952 indicates that, in this interval, the river thalweg between the head of Tarpley Island and Warfield Point shifted from the left to the right bank. Between Warfield Point and the revetment at the head of Island No. 84 the thalweg migrated from about the middle of the channel to the east bank; no appreciable change occurred in its location along the revetment. However, there has been a minor eastward shift of the channel thalweg around the bar along the Mississippi shore downstream from the Island No. 84 revetment, with formation of a definite channel in this area. In addition, channel depths in the reach extending for about one or two miles upstream from the bridge decreased with a corresponding increase in channel widths. Apparently, the formation of a well-defined channel around the left-bank bar at Island No. 84 with resultant increase in

channel widths and decrease in channel depths in the reach from Walker Bend to the bridge have tended to improve flow conditions at the Greenville Bridge.

64. The movable-bed base test represents a prediction of river conditions for several years from the March-April 1950 prototype hydrographic survey provided improvement works were not installed. Results of this test, which indicated that changes would not occur in the Greenville Bridge reach of sufficient magnitude to shift flow to the right bank farther upstream in Walker Bend, are confirmed by late developments in the prototype.

TABLES

Table 1

VELOCITY OBSERVATIONS, MOVABLE-BED BASE TEST

Range 12 (below Bridge)

Distance in Prototype Feet from 1950 Right Top Bank	Velocities in Prototype Feet Per Second								
	Run 1			Run 2			Run 3		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
200	6	8	-	7	8	-	6	8	-
400	7	9	-	7	10	-	7	8	-
600	7	8	-	7	8	-	7	8	-
800	7	8	-	6	7	-	5	7	-
1000	6	7	-	7	8	-	6	7	-
1200	5	6	-	6	8	-	5	7	-
1400	5	7	-	6	7	-	4	6	-
1600	4	6	-	6	7	-	3	7	-
1800	2	5	-	6	6	-	-	6	-
2000	-	3	-	5	6	-	-	5	-
2200	-	-	-	3	5	-	-	2	-

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 2

VELOCITY OBSERVATIONS, MOVABLE-BED BASE TEST

Range 14 (above Bridge)

Distance in Prototype Feet from 1950 Right Top Bank	Velocities in Prototype Feet Per Second								
	Run 1			Run 2			Run 3		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
400	5	10	-	7	10	-	6	10	-
600	7	10	-	7	11	-	7	10	-
800	7	10	-	7	10	-	7	10	-
1000	7	10	-	6	10	-	6	8	-
1200	7	8	-	7	10	-	6	8	-
1400	6	8	-	7	8	-	6	7	-
1600	6	8	-	6	6	-	-	6	-
1800	4	8	-	5	7	-	-	6	-
2000	-	7	-	3	7	-	-	5	-
2200	-	-	-	3	5	-	-	4	-

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 3

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 7

Range 12

Distance in Prototype Feet from 1950 Right Top Bank	Velocities in Prototype Feet Per Second								
	Run 1			Run 2			Run 3		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
200	-	-	-	-	6	-	-	-	-
400	-	-	-	-	7	8	-	-	-
600	-	-	-	-	6	9	-	-	-
800	-	-	-	-	6	8	-	-	-
1000	-	-	-	-	5	8	-	-	-
1200	-	-	-	-	5	8	-	-	-
1400	-	-	-	-	4	7	-	-	-
1600	-	-	-	-	3	6	-	-	-
1800	-	-	-	-	-	5	-	-	-
2000	-	-	-	-	-	3	-	-	-

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 4

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 7

Range 14

Distance in Prototype Feet from 1950 Right Top Bank	Velocities in Prototype Feet Per Second								
	Run 1			Run 2			Run 3		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
400	7	8	-	6	8	8	6	8	7
600	7	9	-	6	8	10	7	9	9
800	6	8	-	5	7	9	6	8	9
1000	6	8	-	4	7	9	6	9	9
1200	6	8	-	4	6	9	6	8	9
1400	5	8	-	4	6	8	6	8	8
1600	5	7	-	3	6	8	6	7	8
1800	4	7	-	-	5	8	5	7	7
2000	3	6	-	-	4	7	4	7	7
2200	-	5	-	-	3	6	-	6	7
2400	-	4	-	-	-	5	-	5	5
2600	-	-	-	-	-	3	-	3	4

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 5

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 7

Range 30

Distance in Prototype Feet from 1950 Left Top Bank	Velocities in Prototype Feet Per Second								
	Run 1			Run 2			Run 3		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
600	-	4	-	-	-	-	-	-	-
800	-	7	-	-	-	-	-	-	-
1200	-	8	-	-	-	-	-	-	-
1800	7	8	-	-	-	-	-	-	-
2000	7	8	-	7	-	-	-	-	-
2400	6	9	-	7	-	-	-	-	-
2800	5	8	-	7	-	-	-	-	-
3200	5	8	-	6	-	-	-	-	-
3600	4	7	-	5	-	-	-	-	-
3800	4	6	-	5	-	-	-	-	-
4000	5	6	-	5	-	-	-	-	-
4200	5	4	-	4	-	-	-	-	-

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 6

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 7

Range 63

Distance in Prototype Feet from 1950 Left Top Bank	Velocities in Prototype Feet Per Second								
	Run 1			Run 2			Run 3		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
2400	-	-	-	-	-	-	3	-	-
2800	-	-	-	-	-	-	3	-	-
3200	-	-	-	-	-	-	4	-	-
3600	-	-	-	-	-	-	5	5	-
4000	-	-	-	-	-	-	6	7	-
4400	-	-	-	-	-	-	7	8	-
4600	-	-	-	-	-	-	8	-	-
4800	-	-	-	-	-	-	7	6	-
5000	-	-	-	-	-	-	-	6	-
5600	-	-	-	-	-	-	-	5	-

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 7

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 8

Range 12

Distance in Prototype Feet from 1950 Right Top Bank	Velocities in Prototype Feet Per Second											
	Run 1			Run 2			Run 3			Run 4		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
200	-	-	7	5	-	7	-	-	7	4	6	7
400	-	-	9	6	-	7	6	-	10	7	7	8
600	-	-	9	5	-	8	6	-	8	6	7	8
800	-	-	10	5	-	8	5	-	8	6	8	9
1000	-	-	9	5	-	7	4	-	8	5	7	9
1200	-	-	8	3	-	7	4	-	7	4	6	8
1400	-	-	7	3	-	6	3	-	6	4	5	7
1600	-	-	6	2	-	7	-	-	6	-	4	6
1800	-	-	6	-	-	5	-	-	-	-	4	3
2000	-	-	4	-	-	4	-	-	-	-	-	3

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 8

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 8

Range 14

Distance in Prototype Feet from 1950 Right Top Bank	Velocities in Prototype Feet Per Second											
	Run 1			Run 2			Run 3			Run 4		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
400	7	9	12	6	8	9	5	8	7	6	7	10
600	8	10	11	6	8	10	7	9	10	7	9	10
800	7	8	12	6	8	11	6	8	10	5	9	10
1000	7	8	10	6	7	9	6	8	9	4	8	10
1200	7	8	9	5	7	9	5	7	9	5	8	9
1400	6	8	9	5	6	8	4	7	9	4	7	9
1600	6	7	9	4	6	8	3	6	9	-	6	8
1800	5	7	9	3	6	8	-	5	8	-	6	8
2000	-	6	8	-	5	7	-	5	8	-	5	7
2200	-	6	7	-	5	6	-	4	7	-	5	7
2400	-	5	6	-	3	6	-	-	6	-	4	6
2600	-	-	6	-	-	4	-	-	5	-	-	6

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

Table 9

VELOCITY OBSERVATIONS, MOVABLE-BED TEST 8

Range 53

Distance in Prototype Feet from 1950 Left Top Bank	Velocities in Prototype Feet Per Second											
	Run 1			Run 2			Run 3			Run 4		
	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage	20-Ft Rising Stage	30-Ft Rising Stage	35-Ft Rising Stage
600	-	-	6	4	8	7	8	9	8	7	-	-
800	6	7	8	9	9	9	7	8	10	9	-	8
1000	7	9	9	7	10	10	7	9	10	9	-	8
1200	7	10	9	7	8	10	7	9	10	7	-	8
1400	6	10	9	7	8	11	6	9	10	6	-	8
1600	5	6	8	7	8	10	6	9	10	6	-	8
1800	5	7	9	6	7	8	5	8	9	5	-	8
2000	5	6	7	5	7	8	3	7	8	-	-	8
2200	5	7	8	5	6	7	-	6	8	-	-	8
2400	5	7	6	4	6	6	-	-	7	-	-	7
2600	5	6	6	-	5	5	-	-	-	-	-	6
2800	-	3	4	-	4	5	-	-	-	-	-	-
5000	-	-	-	-	3	5	-	5	6	-	-	6
5200	-	-	5	-	4	6	-	5	7	-	-	7
5400	-	5	7	-	4	5	-	5	7	-	-	7
5600	-	-	7	-	4	6	-	4	7	-	-	8
5800	-	-	7	-	5	-	-	4	7	-	-	9
6000	-	-	7	-	3	5	-	5	7	-	-	8
6200	-	-	7	-	5	6	-	5	7	-	-	8
6400	-	-	6	-	5	6	-	6	7	-	-	8
6600	-	-	6	-	-	-	-	6	7	-	-	8
6800	-	-	5	-	-	-	-	-	6	-	-	7
7000	-	-	5	-	-	-	-	-	-	-	-	-

Note: All velocities were obtained with a miniature current meter at a depth of 8 ft prototype.

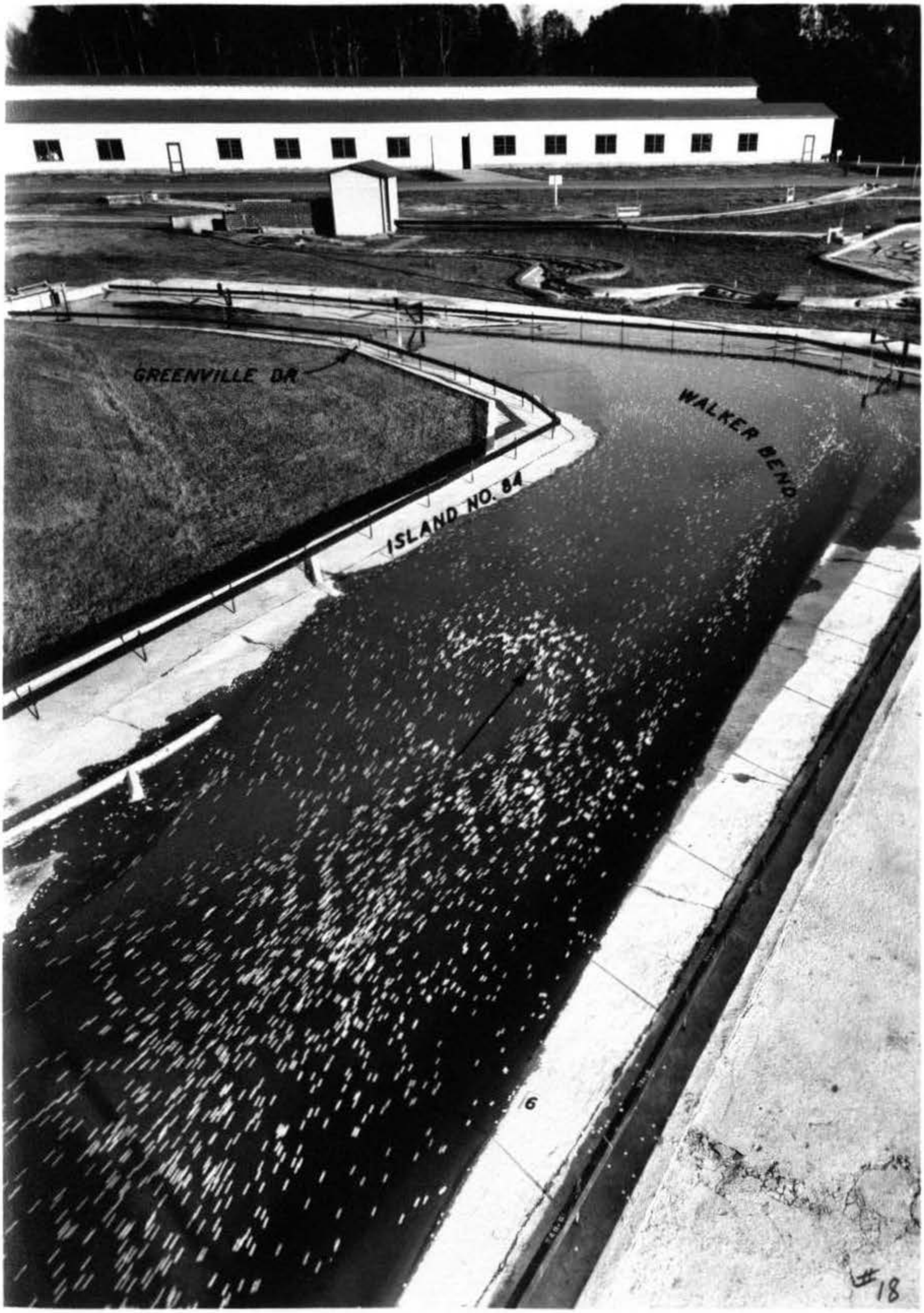
PHOTOGRAPHS

Photograph 1. Fixed-bed test 1, 35-ft stage. Downstream view showing current directions with 5000-ft dike on left bank below Warfield Point. Note concentration of flow along dike and eddy behind lower end of dike

Photograph 2. Fixed-bed test 2, 35-ft stage. Downstream view showing current directions with 9100-ft dike on left bank below Warfield Point. Note concentration of flow along dike

Photograph 3. Fixed-bed test 3, 35-ft stage. Downstream view showing current directions with 9100-ft dike on left bank below Warfield Point and deepened channel opposite dike. Compare with photograph 2

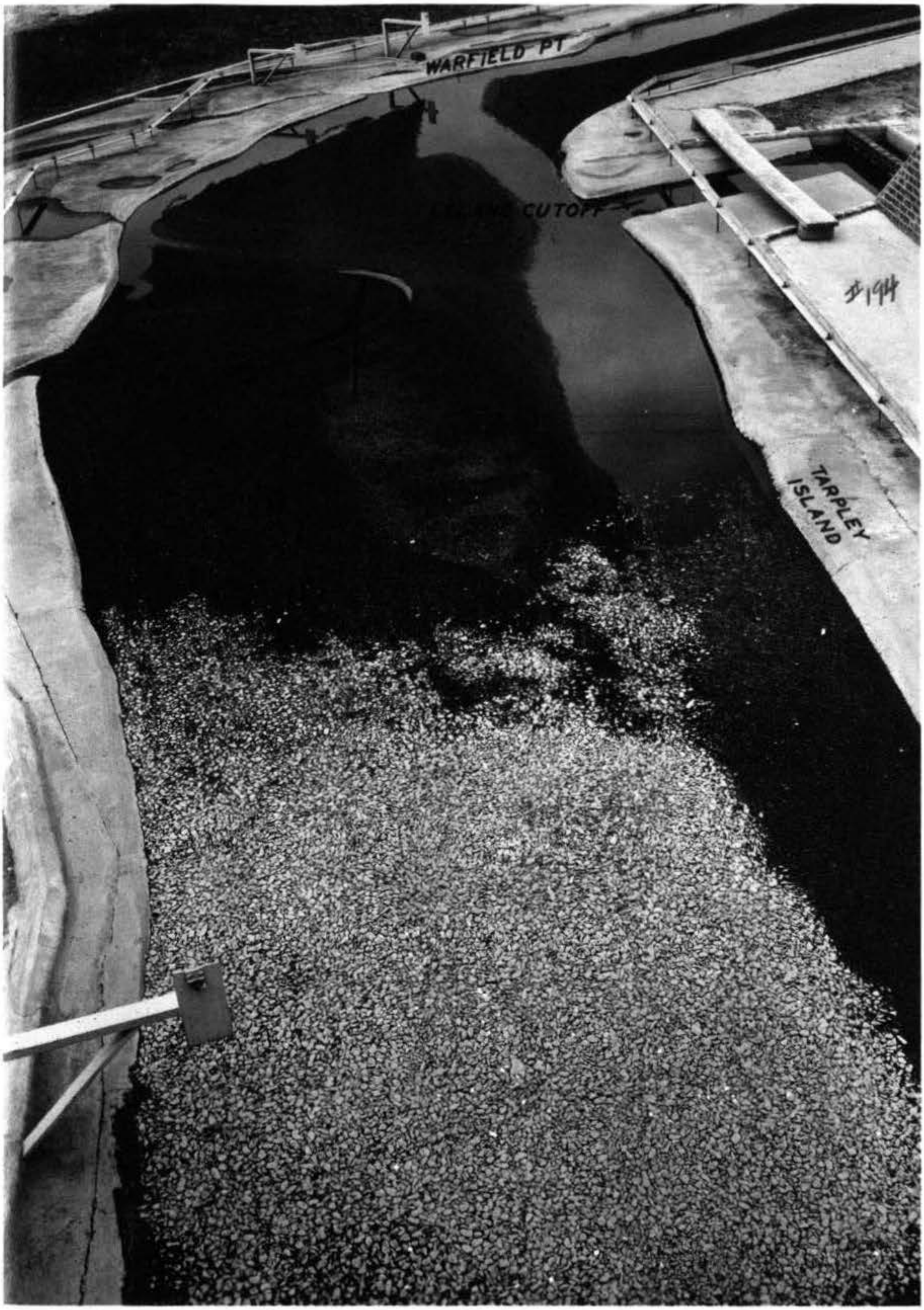
Photograph 4. Fixed-bed test 6, 35-ft stage. Downstream view showing current directions in vicinity of Warfield Point where left bank was realigned. Center bar opposite bank was covered with sand



Photograph 5. Fixed-bed test 6, 35-ft stage. Downstream view showing current directions in vicinity of Walker Bend. Right bank was realigned and center bar covered with sand

Photograph 6. Movable-bed base test, dry bed. Downstream view showing channel configurations upstream from Warfield Point at end of run 1

Photograph 7. Movable-bed base test, dry bed. Downstream view showing channel configurations in vicinity of and downstream from Warfield Point at end of run 1



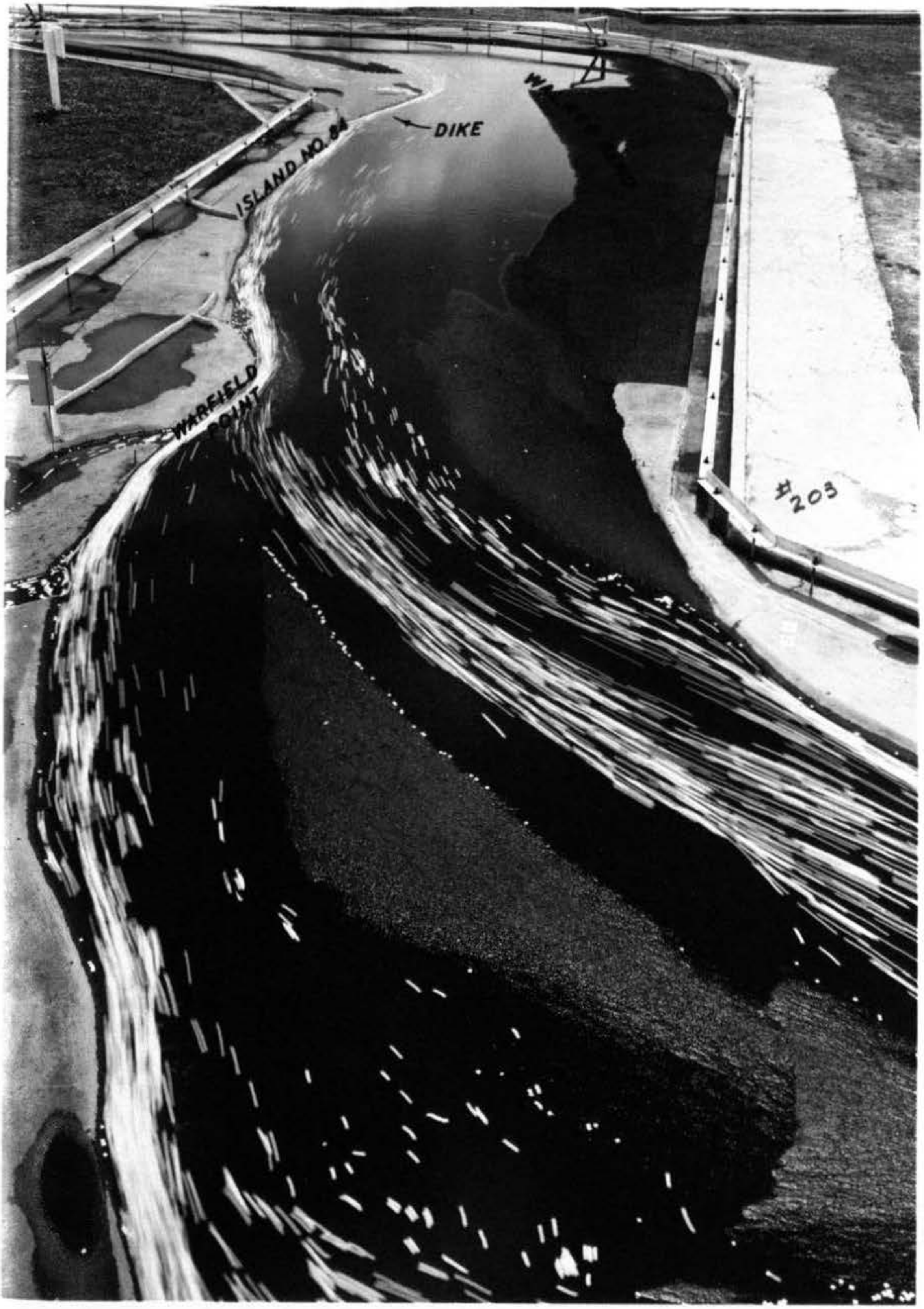
Photograph 8. Movable-bed base test, dry bed. Downstream view showing channel configurations upstream from Warfield Point at end of test

Photograph 9. Movable-bed base test, dry bed. Downstream view showing channel configurations in vicinity of and downstream from Warfield Point at end of test

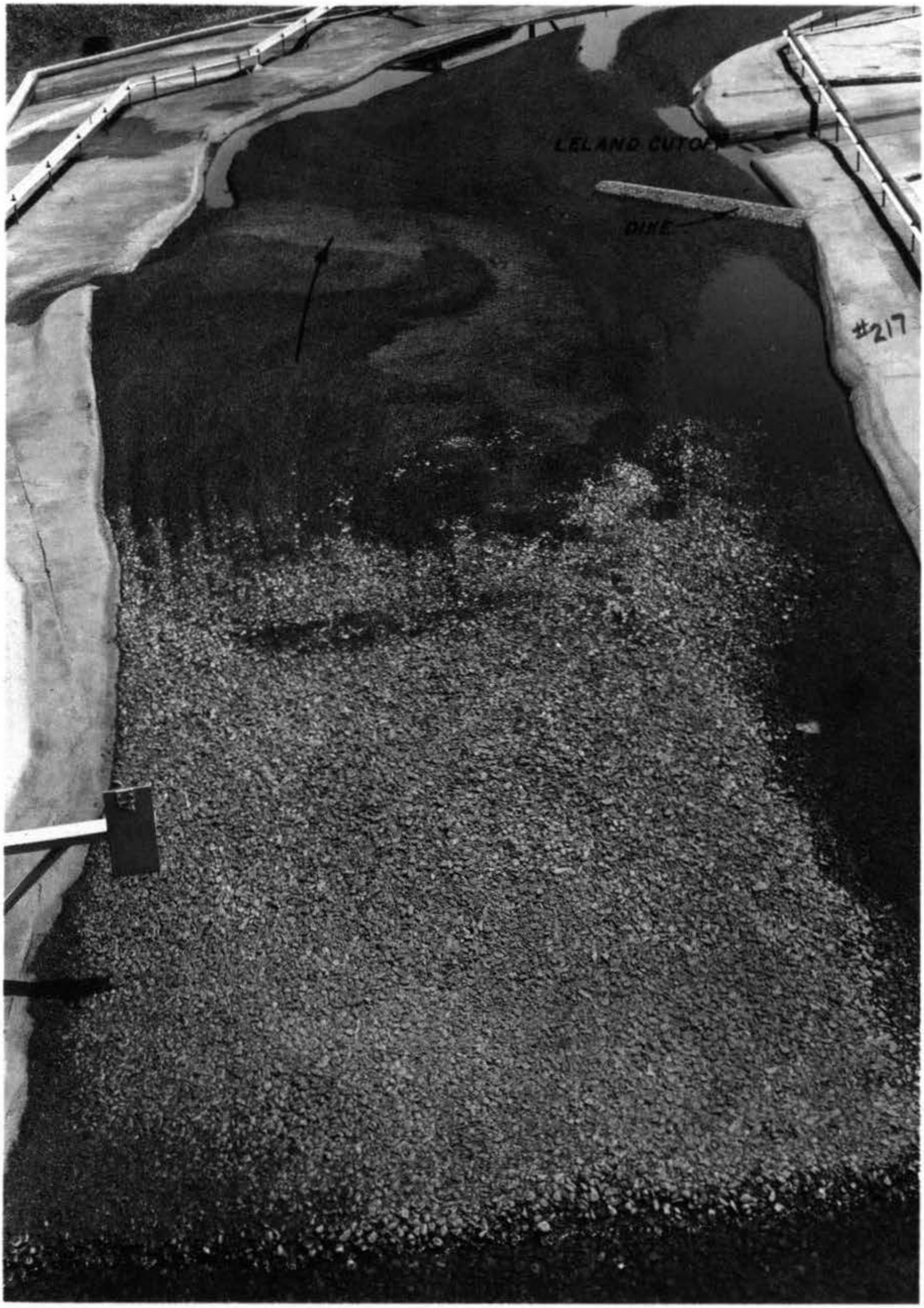
Photograph 10. Movable-bed test 7, start of test. Downstream view showing channel configurations in vicinity of Warfield Point. Note dike extending out from left bank just upstream from Island 84

Photograph 11. Movable-bed test 7, end run 1. Downstream view showing channel configurations in vicinity of Warfield Point

Photograph 12. Movable-bed test 7, 35-ft stage. Downstream view showing current directions in vicinity of Warfield Point during run 1. Note flow over top of left-bank dike just upstream from Island 84



Photograph 13. Movable-bed test 7, 5-ft (falling) stage. Downstream view showing current directions in vicinity of Warfield Point during run 1. Note concentration of flow along left bank downstream from Warfield Point

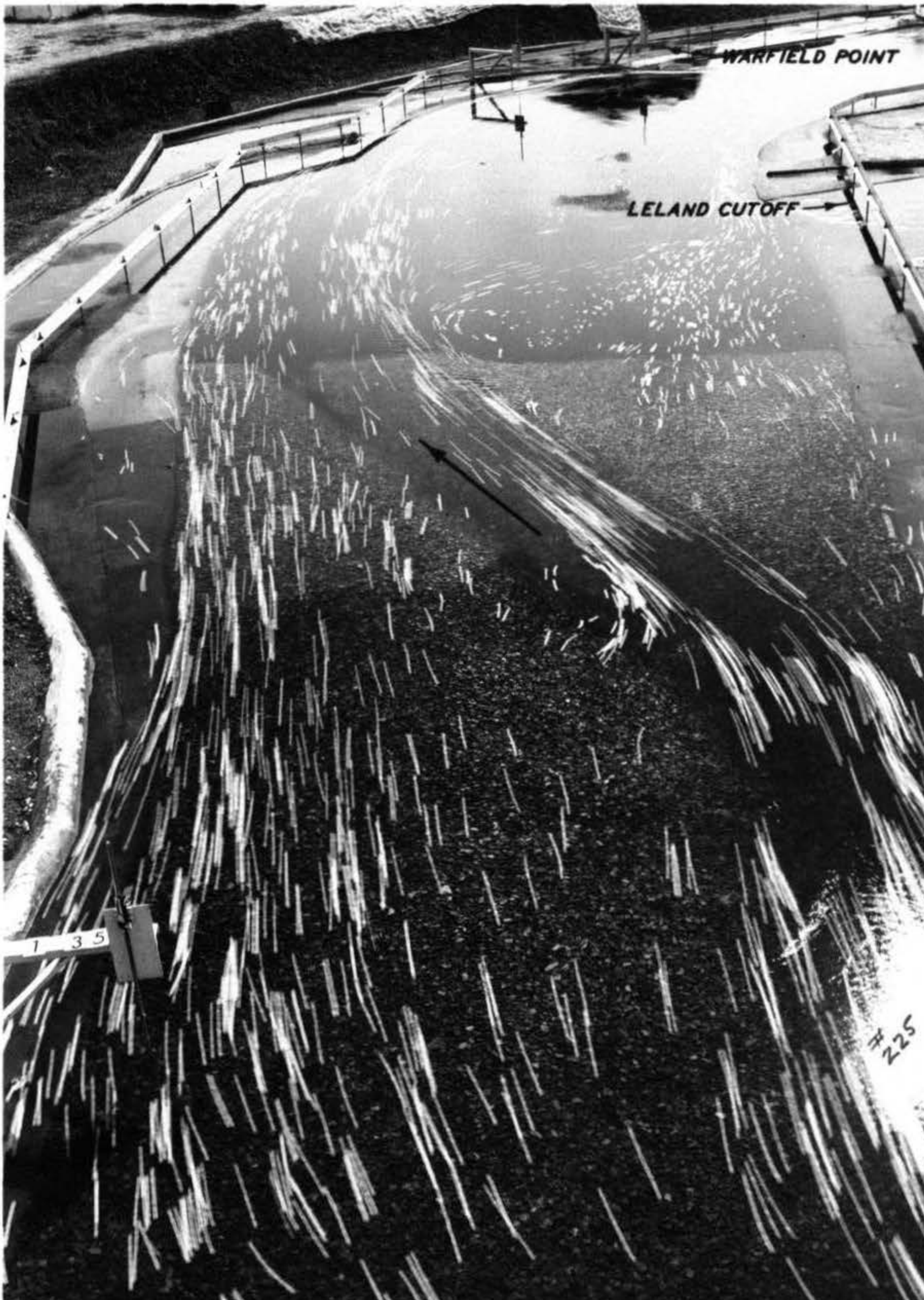


Photograph 14. Movable-bed test 7, start of run 3. Downstream view showing supplementary dike installed along right bank just upstream from Leland Neck

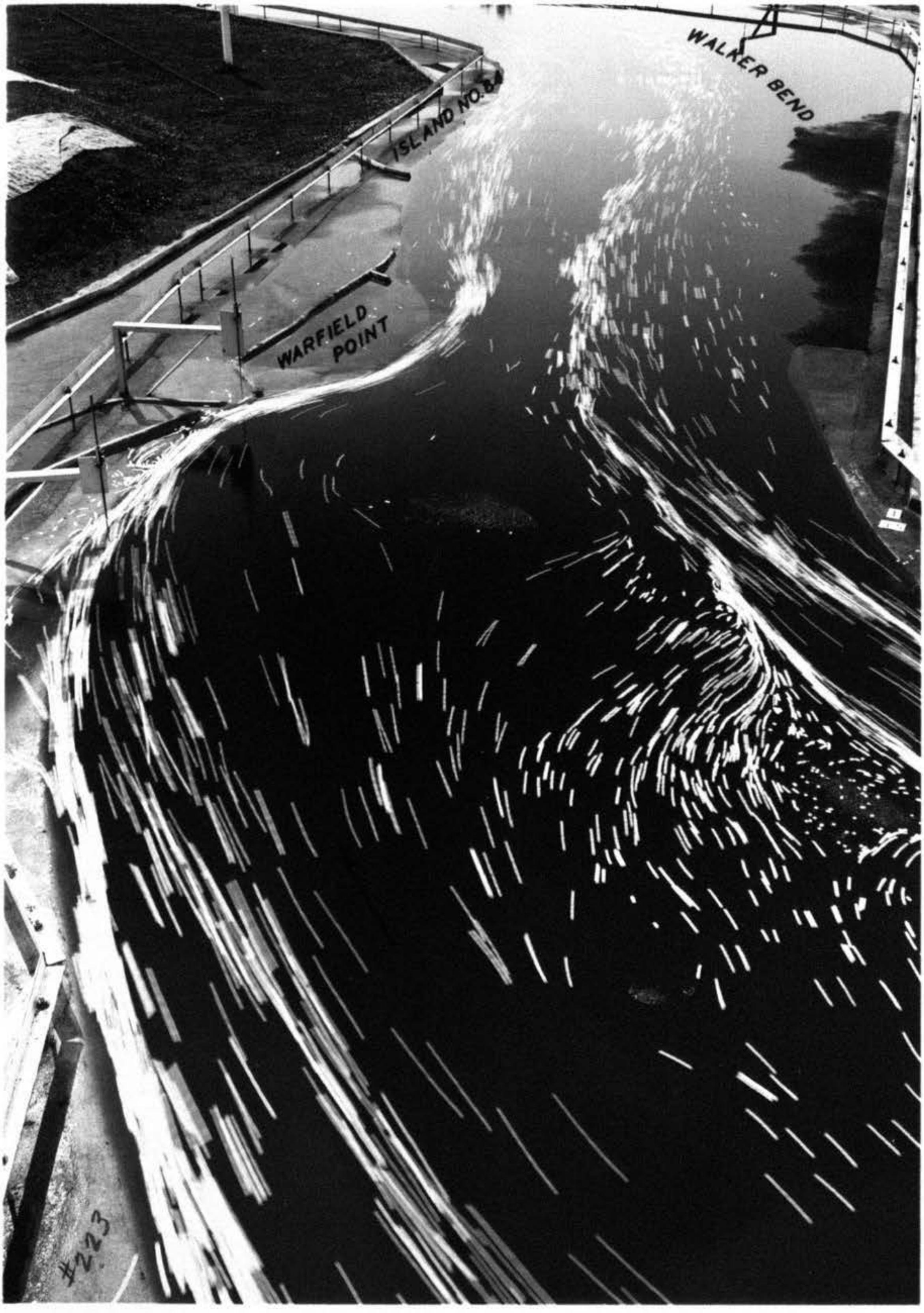
Photograph 15. Movable-bed test 7, end of test. Downstream view showing channel configurations just upstream from Warfield Point. Note outline of cut dredged on 15-ft (falling) stage of run 3

Photograph 16. Movable-bed test 7, end of test. Downstream view showing channel configurations in vicinity of Warfield Point

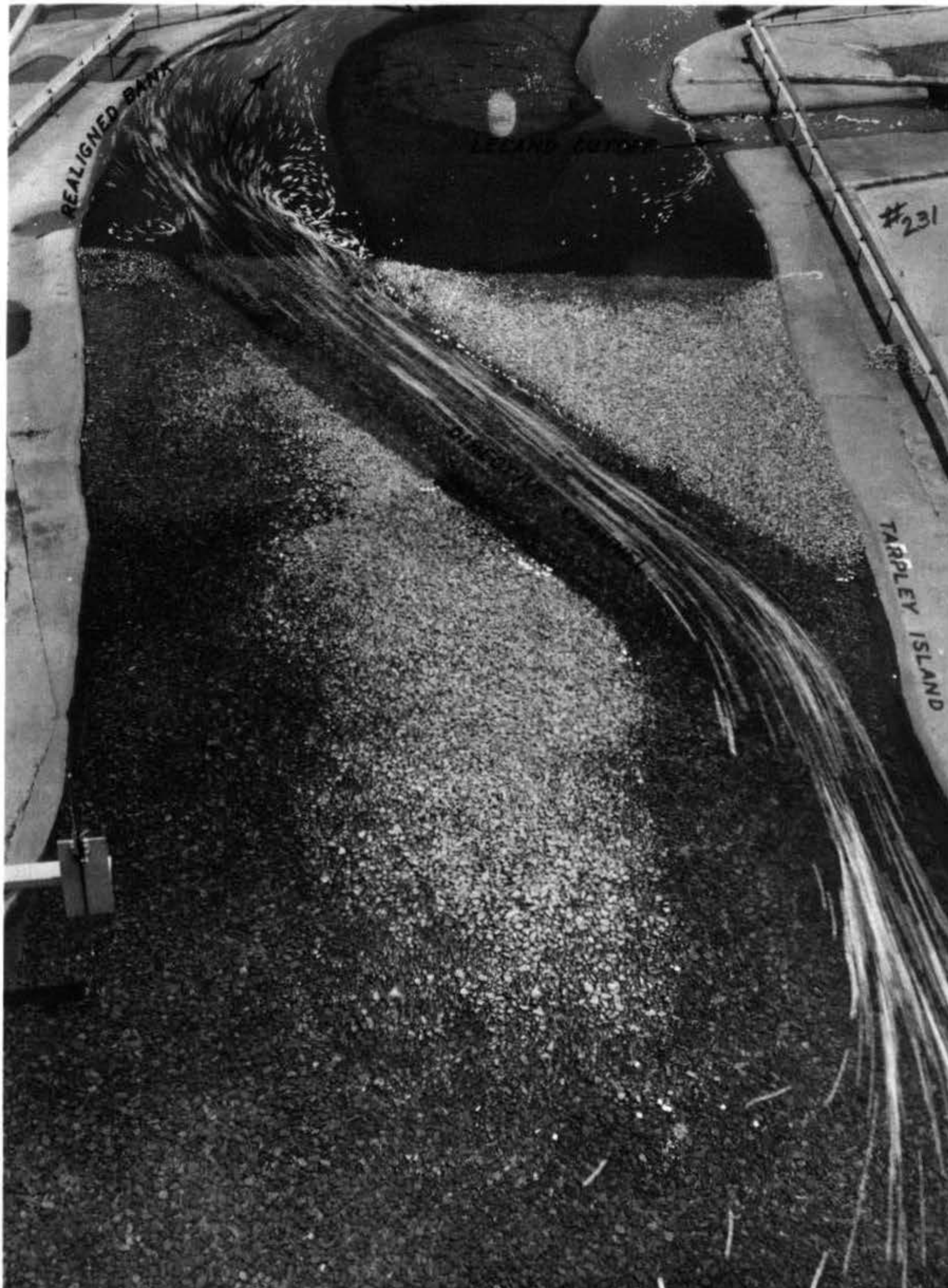
Photograph 17. Movable-bed test 8, start of test. Downstream view showing proposed channel realignment in crossing just upstream from Warfield Point. Left bank also has been realigned eastward



Photograph 18. Movable-bed test 8, 35-ft stage. Downstream view showing current directions in reach upstream from Warfield Point during run 1



Photograph 19. Movable-bed test 8, 35-ft stage. Downstream view showing current directions in vicinity of Warfield Point during run 1. Note tendency of flow past Warfield Point to remain near left bank



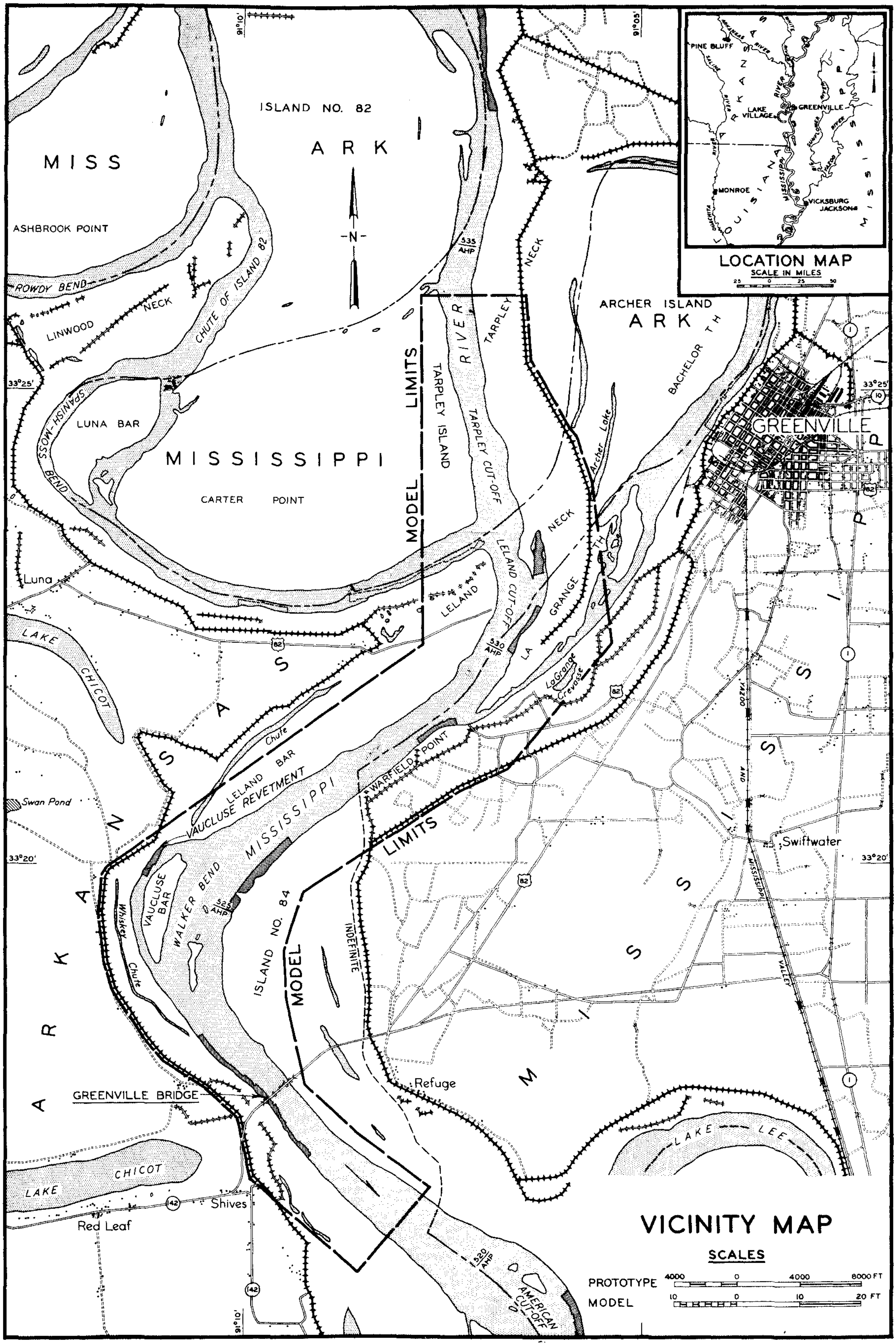
Photograph 20. Movable-bed test 8, 5-ft (falling) stage. Downstream view showing current directions in reach upstream from Warfield Point during run 1

Photograph 21. Movable-bed test 8, 5-ft (falling) stage. Downstream view showing current directions in vicinity of Warfield Point during run 1. Note concentration of flow along left bank below Warfield Point

Photograph 22. Movable-bed test 8, end of test. Downstream view showing channel configurations in reach upstream from Warfield Point

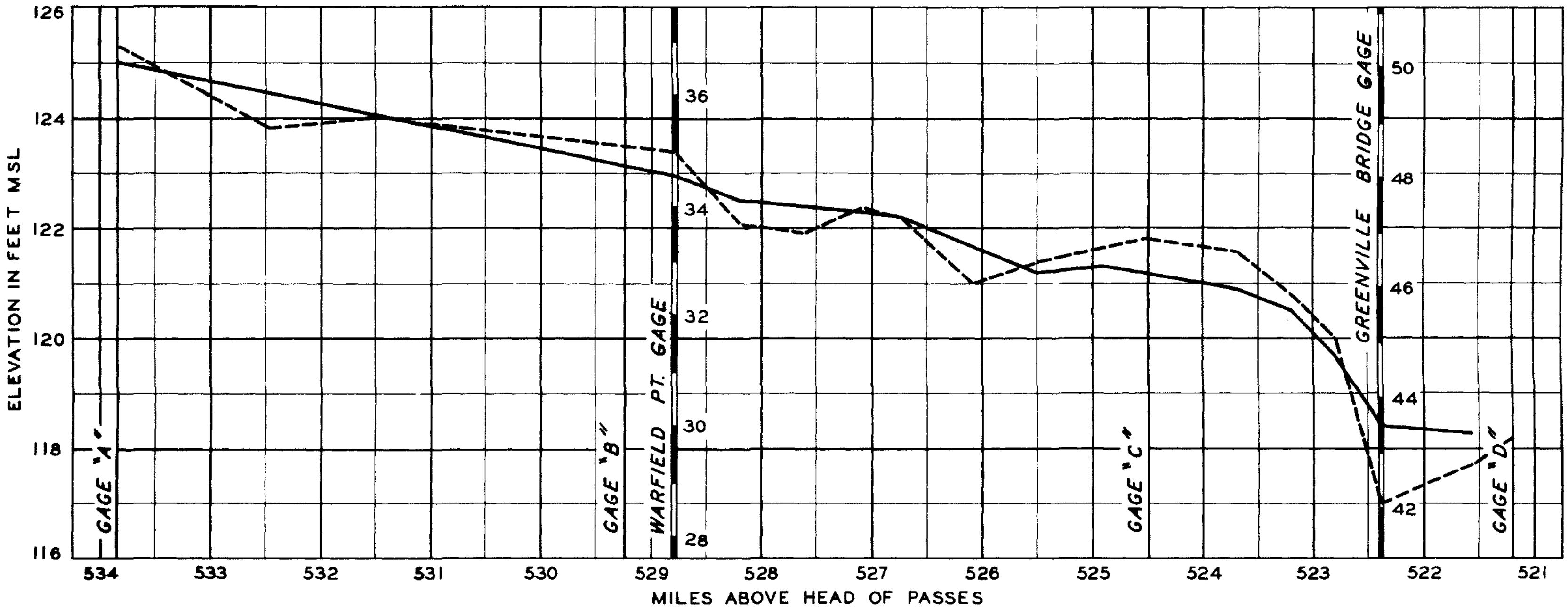
Photograph 23. Movable-bed test 8, end of test. Downstream view showing channel configurations in vicinity of Warfield Point. Note alignment of channel between Warfield Point and Walker Bend

PLATES



LOCATION MAP
SCALE IN MILES
PINE BLUFF
GREENVILLE
LAKE VILLAGE
MONROE
VICKSBURG
JACKSON
ISLAND NO. 82
MISS
ARK
ASHBROOK POINT
ROWDY BEND
LINWOOD
NECK
CHUTE OF ISLAND 82
SPANISH-MOSS BEND
LUNA BAR
MISSISSIPPI
CARTER POINT
MODEL LIMITS
TARPLEY ISLAND
TARPLEY CUT-OFF
TARPLEY NECK
ARCHER ISLAND
BACHELOR TH
Archer Lake
GREENVILLE
LELAND CUT-OFF
LELAND NECK
LA GRANGE TH
LaGrange Crevasse
LELAND
Luna
LAKE CHICOT
LELAND BAR
Chute
VAUCLUSE REVETMENT
WARFIELD POINT
Swan Pond
VAUCLUSE BAR
WALKER BEND
ISLAND NO. 84
Whiskey Chute
INDEFINITE
Swiftwater
Refuge
GREENVILLE BRIDGE
LAKE LEE
Shives
Red Leaf
AMERICAN CUT-OFF
YAZOO AND MISSISSIPPI VALLEY
VICINITY MAP
SCALES
PROTOTYPE
MODEL

PLATE 1



NOTE: WATER-SURFACE PROFILES REPRESENT AVERAGES
OF GAGE READINGS TAKEN ON RIGHT AND LEFT BANKS.
SEE PLATE 3 FOR GAGE LOCATIONS.

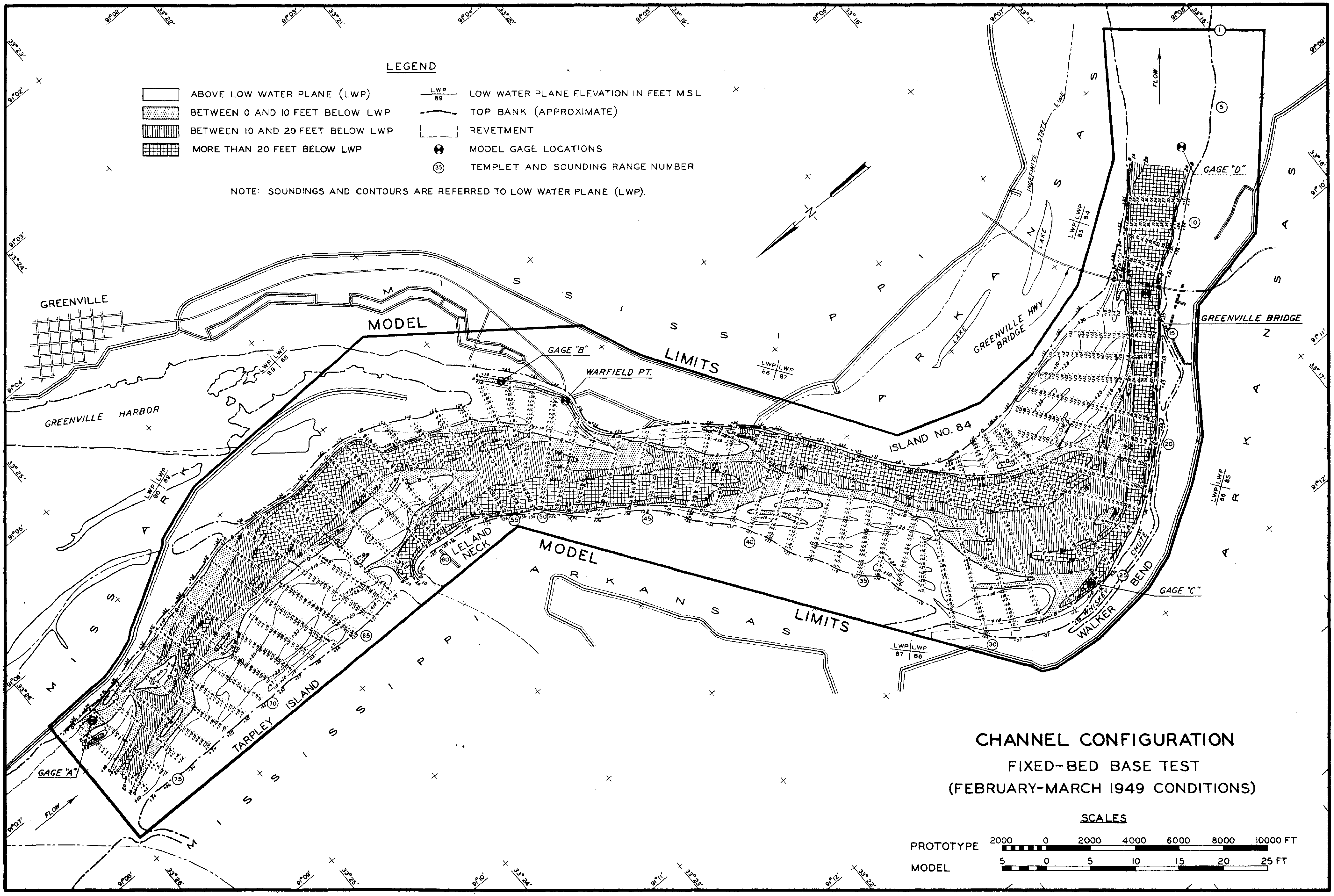
LEGEND

——— 11 MARCH 1949 PROTOTYPE WATER-SURFACE PROFILE

– – – MODEL ADJUSTMENT TEST WATER-SURFACE PROFILE

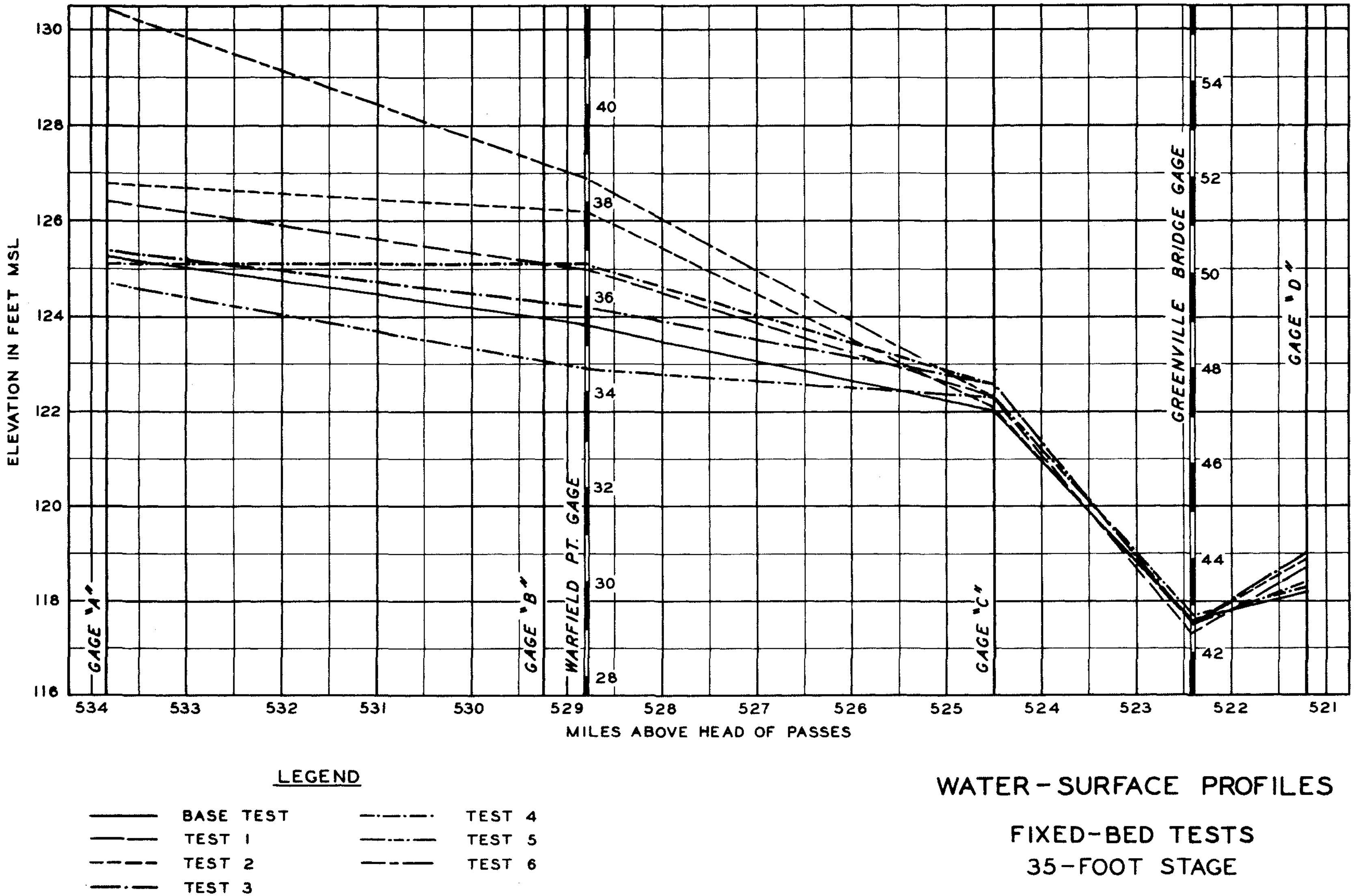
WATER-SURFACE PROFILES

FIXED-BED ADJUSTMENT
35-FOOT STAGE



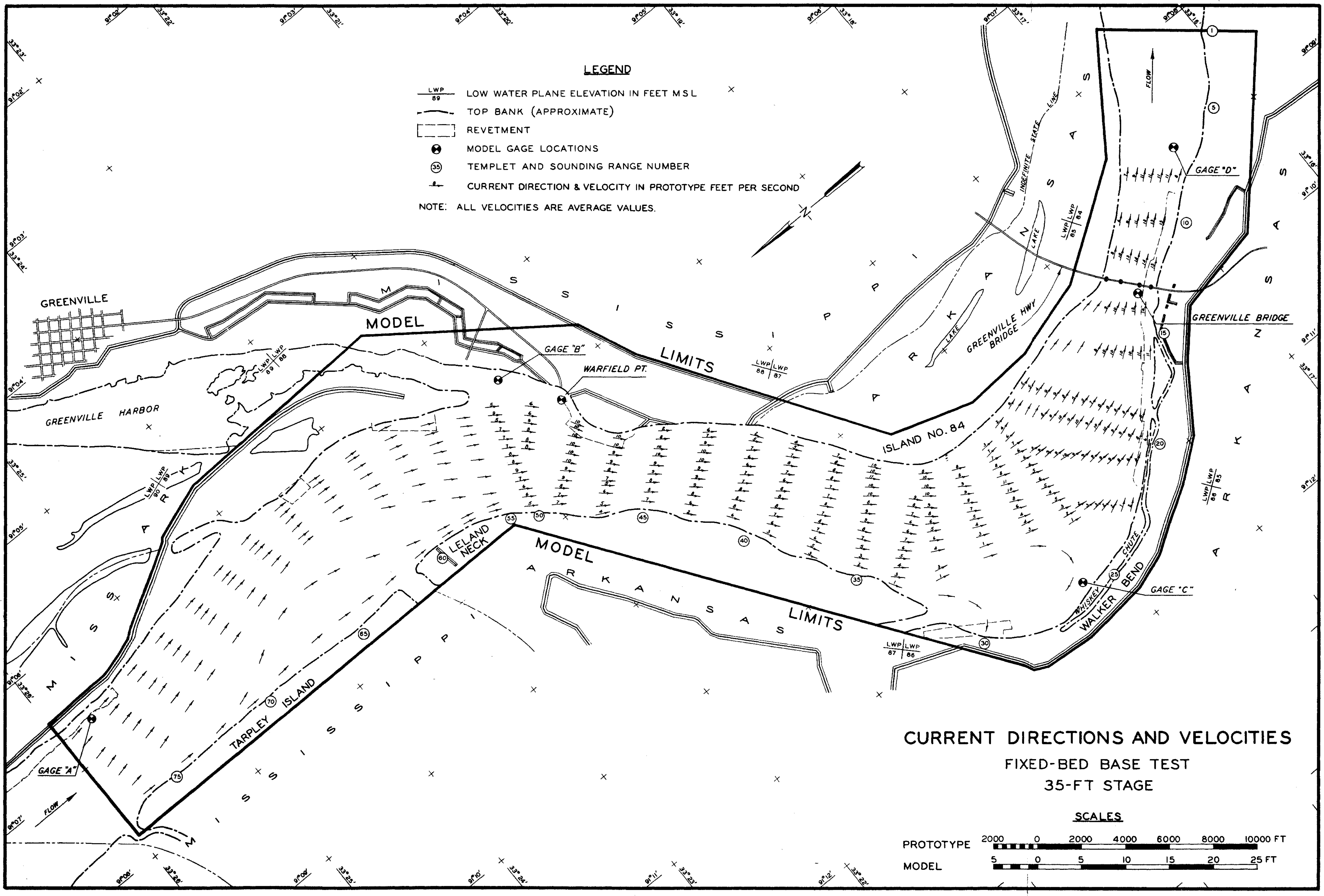
CHANNEL CONFIGURATION
FIXED-BED BASE TEST
(FEBRUARY-MARCH 1949 CONDITIONS)

PLATE 3



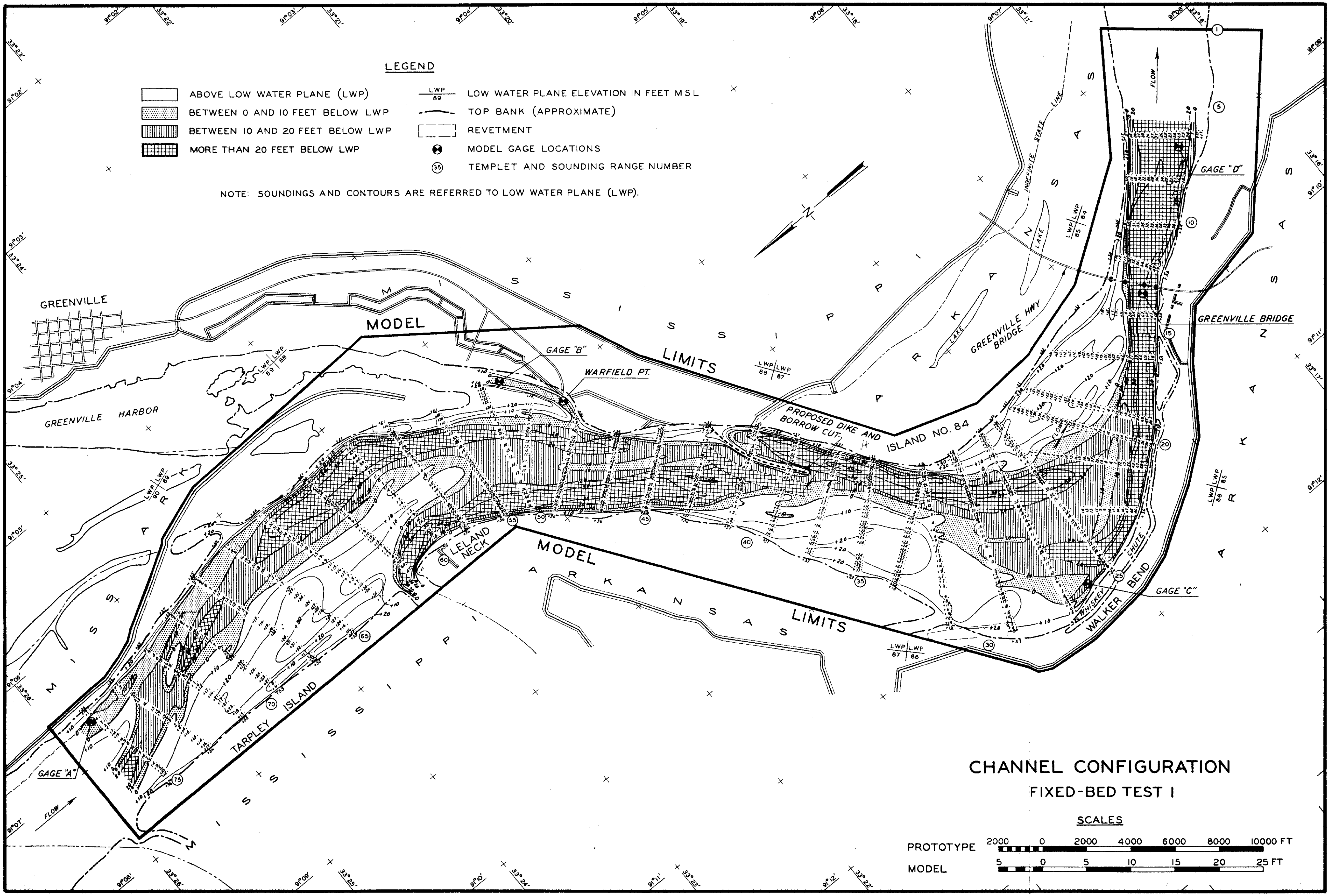
WATER-SURFACE PROFILES

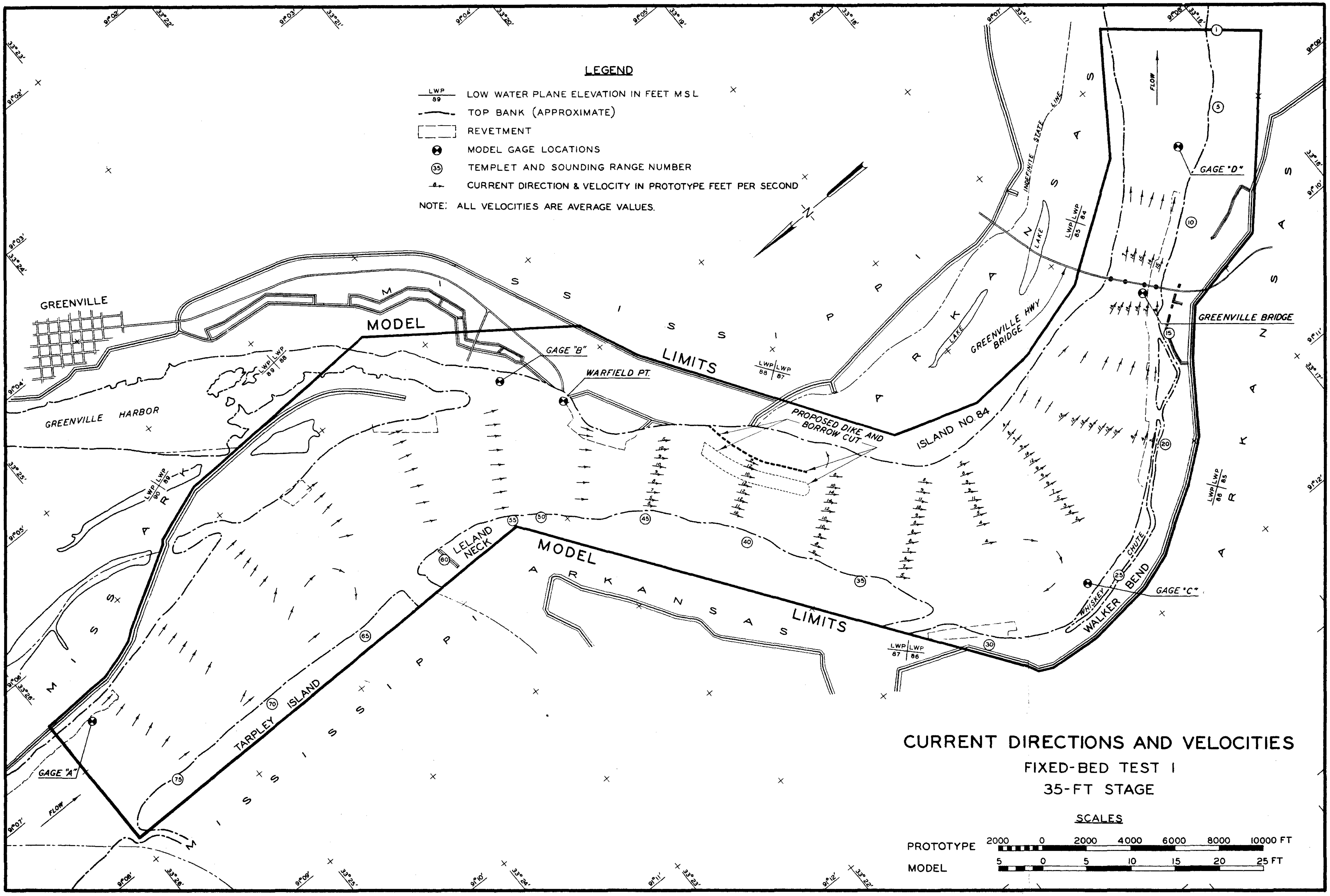
FIXED-BED TESTS
35-FOOT STAGE



LEGEND
LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
TEMPLET AND SOUNDING RANGE NUMBER
CURRENT DIRECTION & VELOCITY IN PROTOTYPE FEET PER SECOND
NOTE: ALL VELOCITIES ARE AVERAGE VALUES.
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "A"
GAGE "B"
GAGE "C"
GAGE "D"
WARFIELD PT.
ISLAND NO. 84
LELAND NECK
TARPLEY ISLAND
WHISKEY CHUTE
WALKER BEND
GREENVILLE BRIDGE
GREENVILLE HWY BRIDGE
INDEFINITE STATE LINE
LAKE
FLOW
MISSISSIPPI
ARKANSAS
CURRENT DIRECTIONS AND VELOCITIES
FIXED-BED BASE TEST
35-FT STAGE
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT

PLATE 5

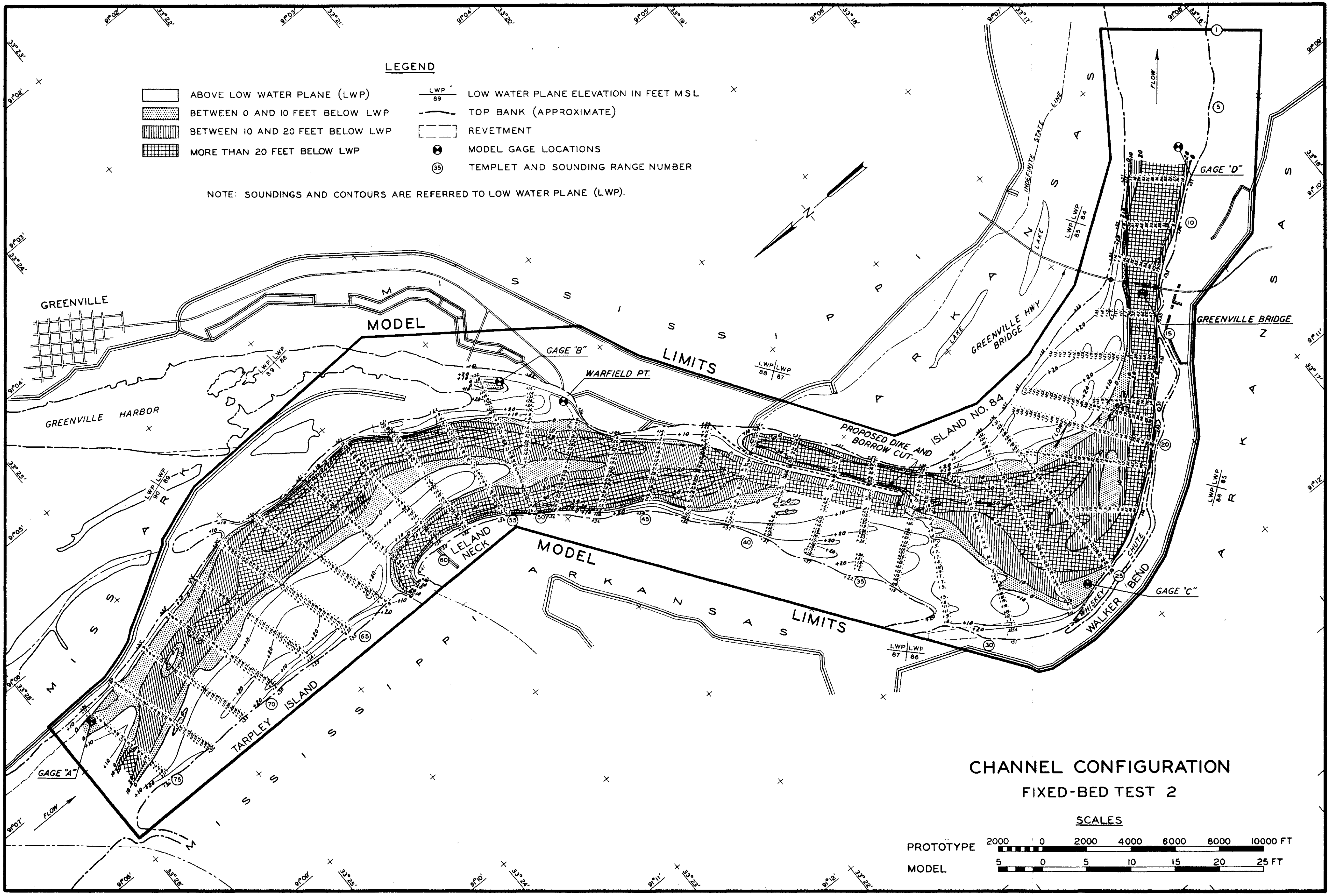

LEGEND
ABOVE LOW WATER PLANE (LWP)
BETWEEN 0 AND 10 FEET BELOW LWP
BETWEEN 10 AND 20 FEET BELOW LWP
MORE THAN 20 FEET BELOW LWP
LWP 89 LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
35 TEMPLET AND SOUNDING RANGE NUMBER
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO LOW WATER PLANE (LWP).
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "B"
WARFIELD PT.
PROPOSED DIKE AND BORROW CUT
ISLAND NO. 84
GREENVILLE HWY BRIDGE
GREENVILLE BRIDGE
GAGE "D"
GAGE "C"
WHISKEY CHUTE
WALKER BEND
LELAND NECK
TARPLEY ISLAND
GAGE "A"
FLOW
MISSISSIPPI
ARKANSAS
INDEFINITE STATE LINE
LAKE
CHANNEL CONFIGURATION
FIXED-BED TEST 1
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT



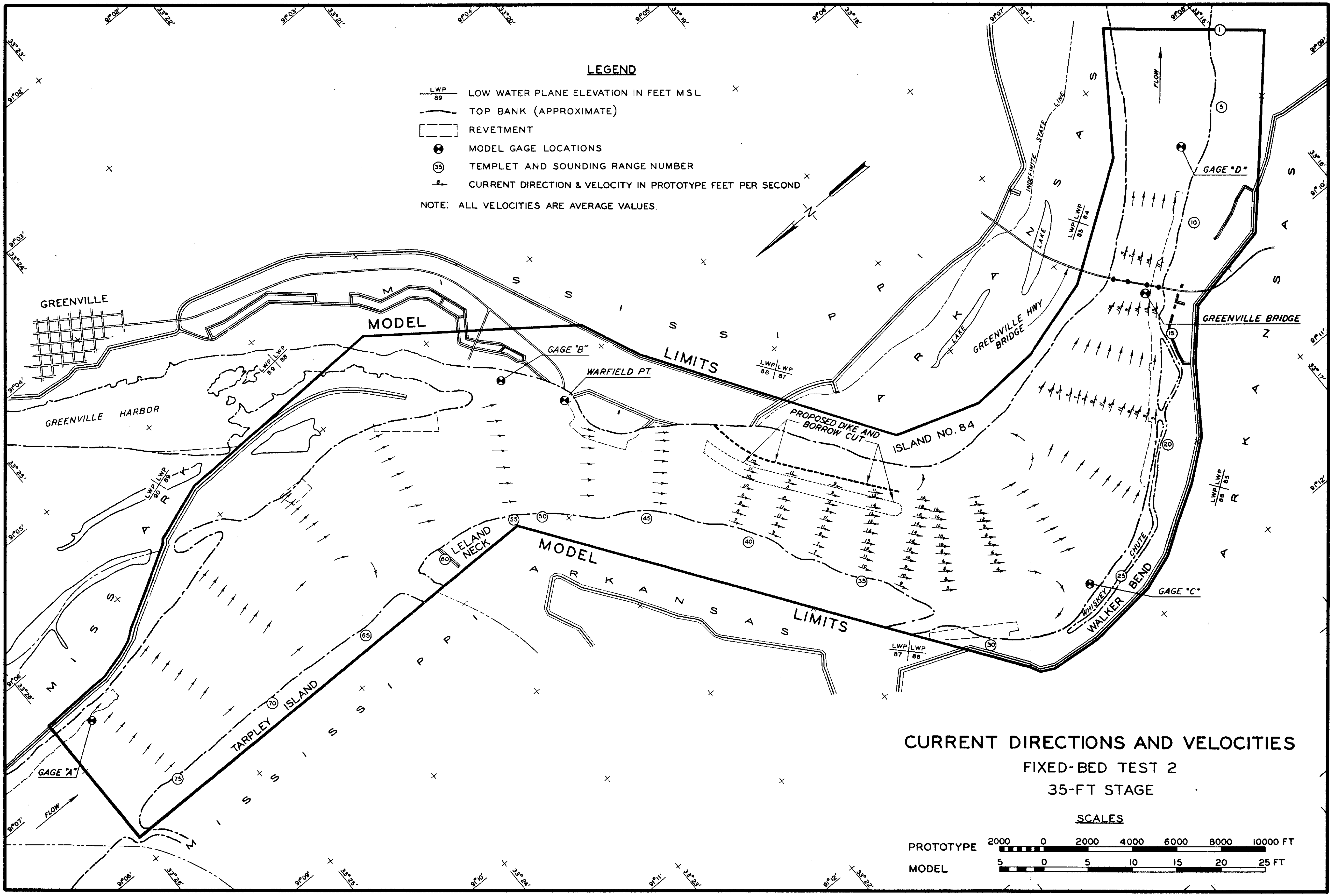
CURRENT DIRECTIONS AND VELOCITIES

FIXED-BED TEST 1

35-FT STAGE



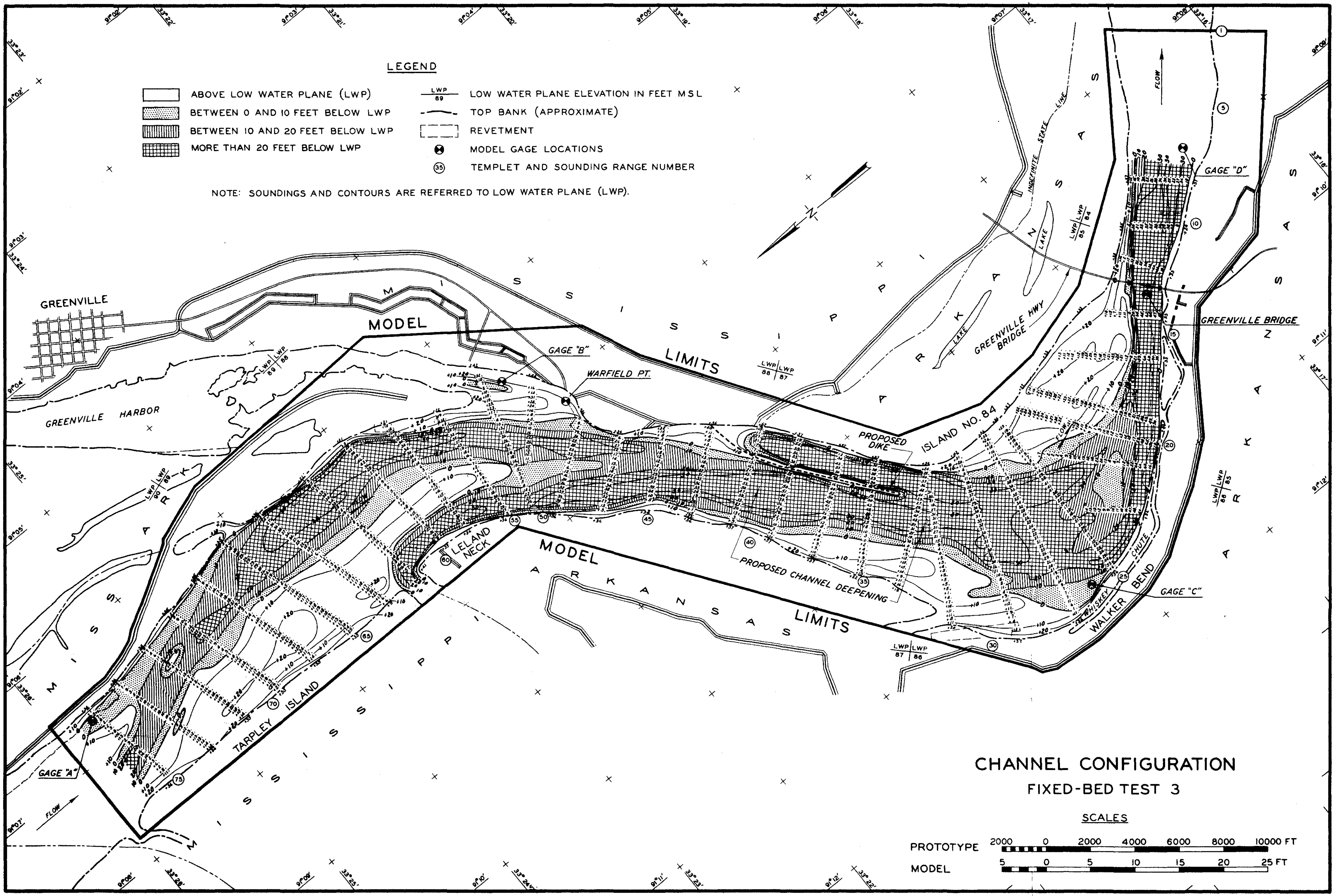
CHANNEL CONFIGURATION
FIXED-BED TEST 2



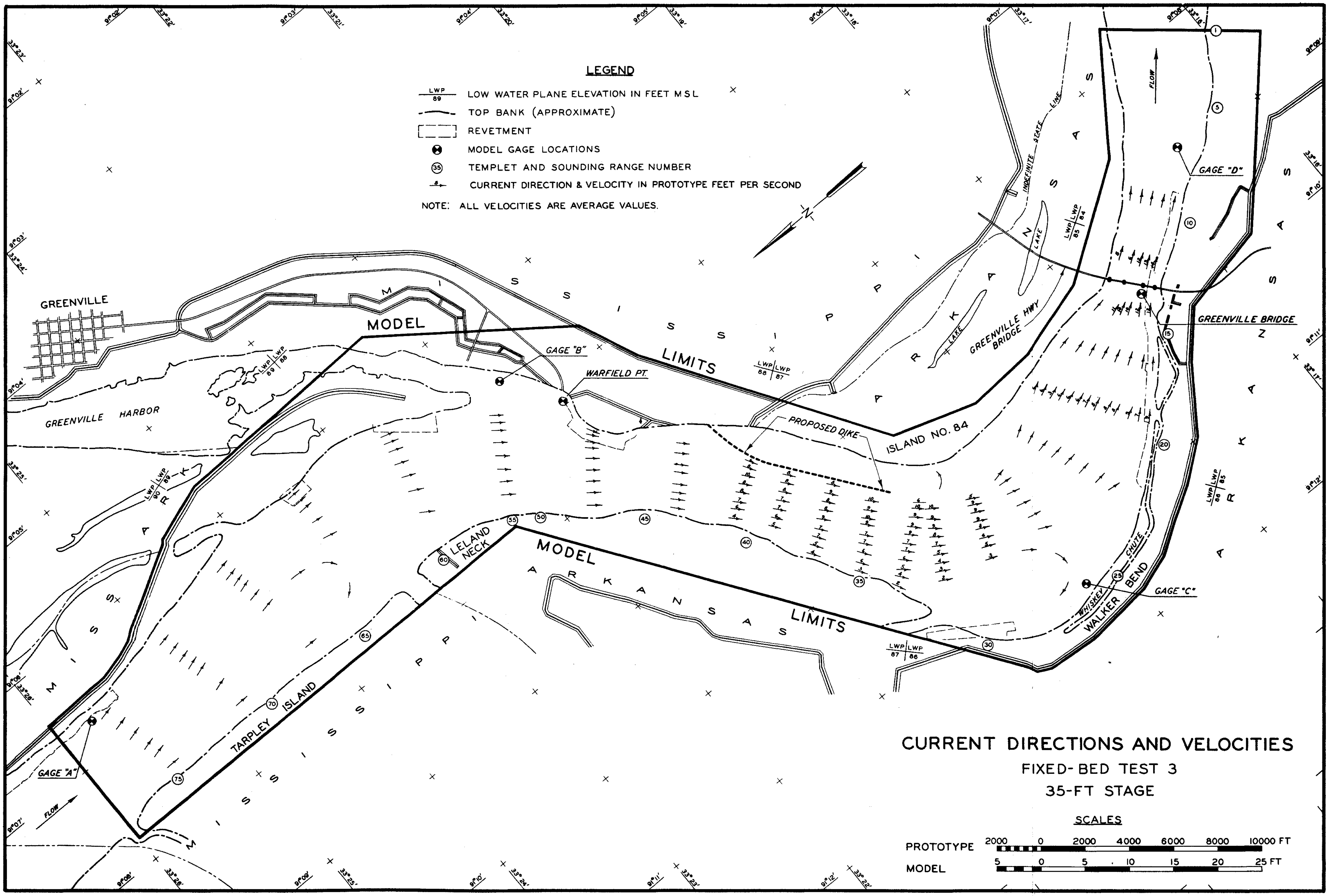
CURRENT DIRECTIONS AND VELOCITIES

FIXED-BED TEST 2

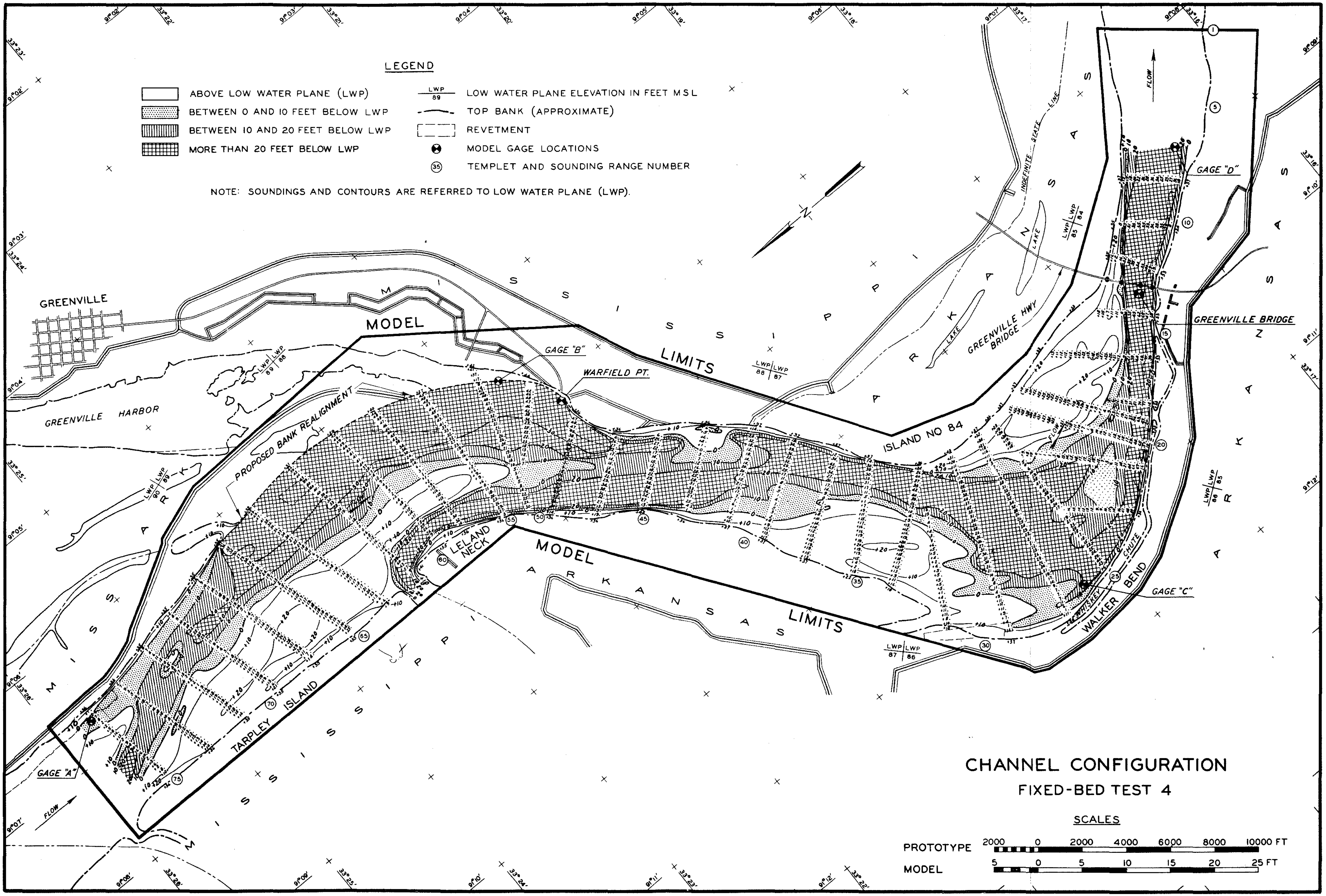
35-FT STAGE



LEGEND
ABOVE LOW WATER PLANE (LWP)
BETWEEN 0 AND 10 FEET BELOW LWP
BETWEEN 10 AND 20 FEET BELOW LWP
MORE THAN 20 FEET BELOW LWP
LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
TEMPLET AND SOUNDING RANGE NUMBER
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO LOW WATER PLANE (LWP).
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "A"
GAGE "B"
GAGE "C"
GAGE "D"
WARFIELD PT.
LELAND NECK
TARPLEY ISLAND
ISLAND NO. 84
PROPOSED DIKE
PROPOSED CHANNEL DEEPENING
GREENVILLE BRIDGE
GREENVILLE HWY BRIDGE
WHISKEY CHUTE
WALKER BEND
INDEFINITE STATE LINE
LAKE
FLOW
MISSISSIPPI
ARKANSAS
CHANNEL CONFIGURATION
FIXED-BED TEST 3
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT

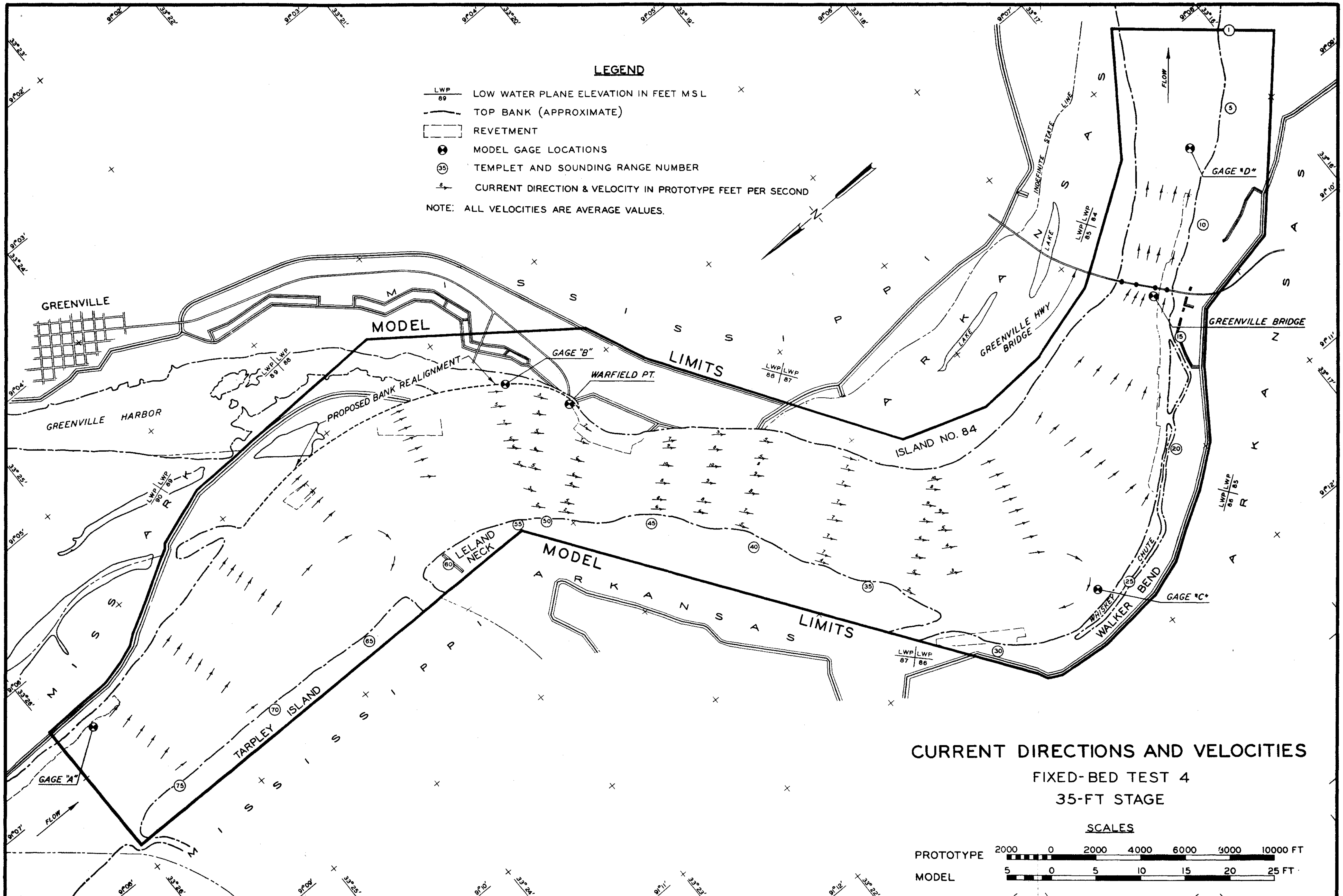


CURRENT DIRECTIONS AND VELOCITIES
FIXED-BED TEST 3
35-FT STAGE



CHANNEL CONFIGURATION

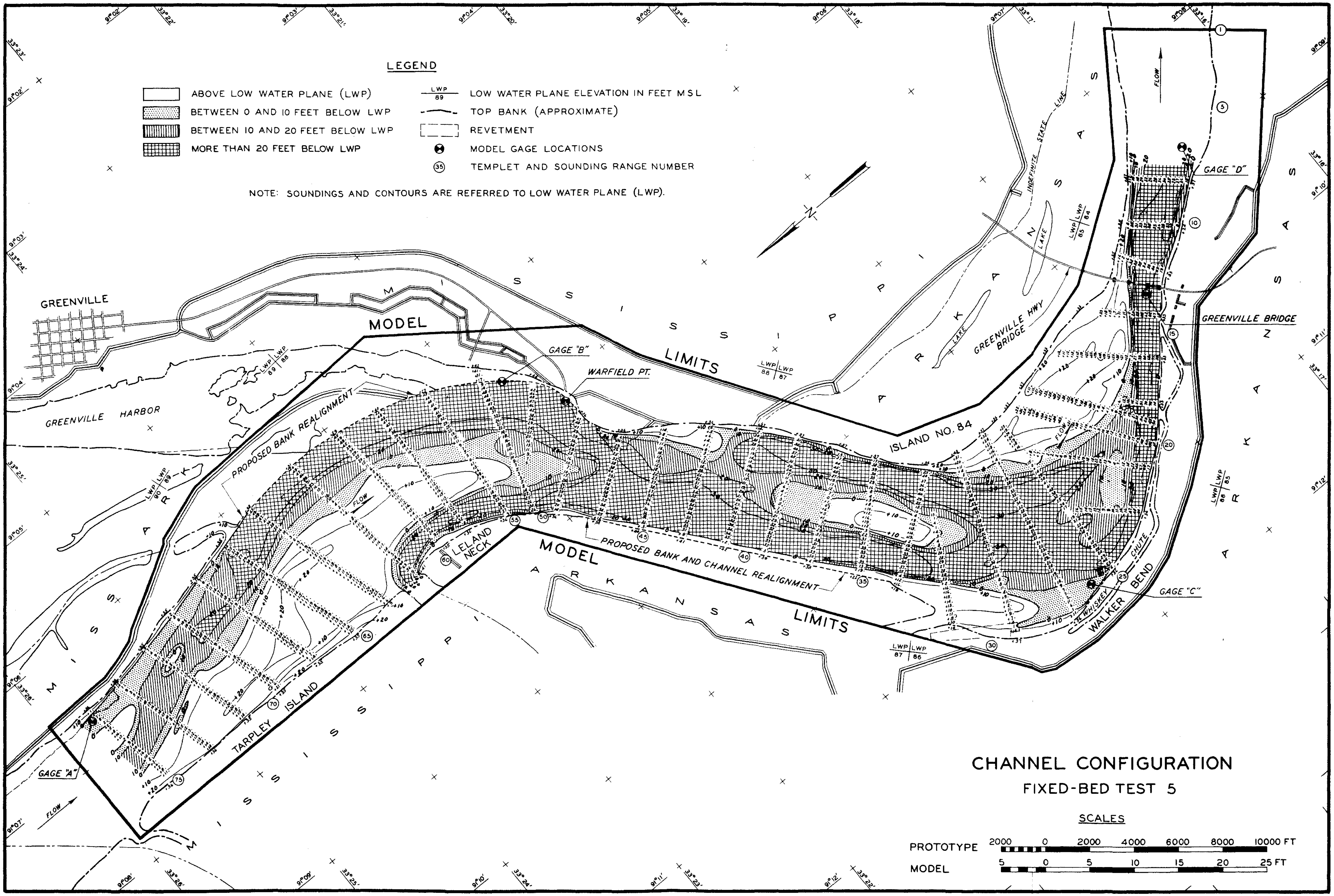
FIXED-BED TEST 4



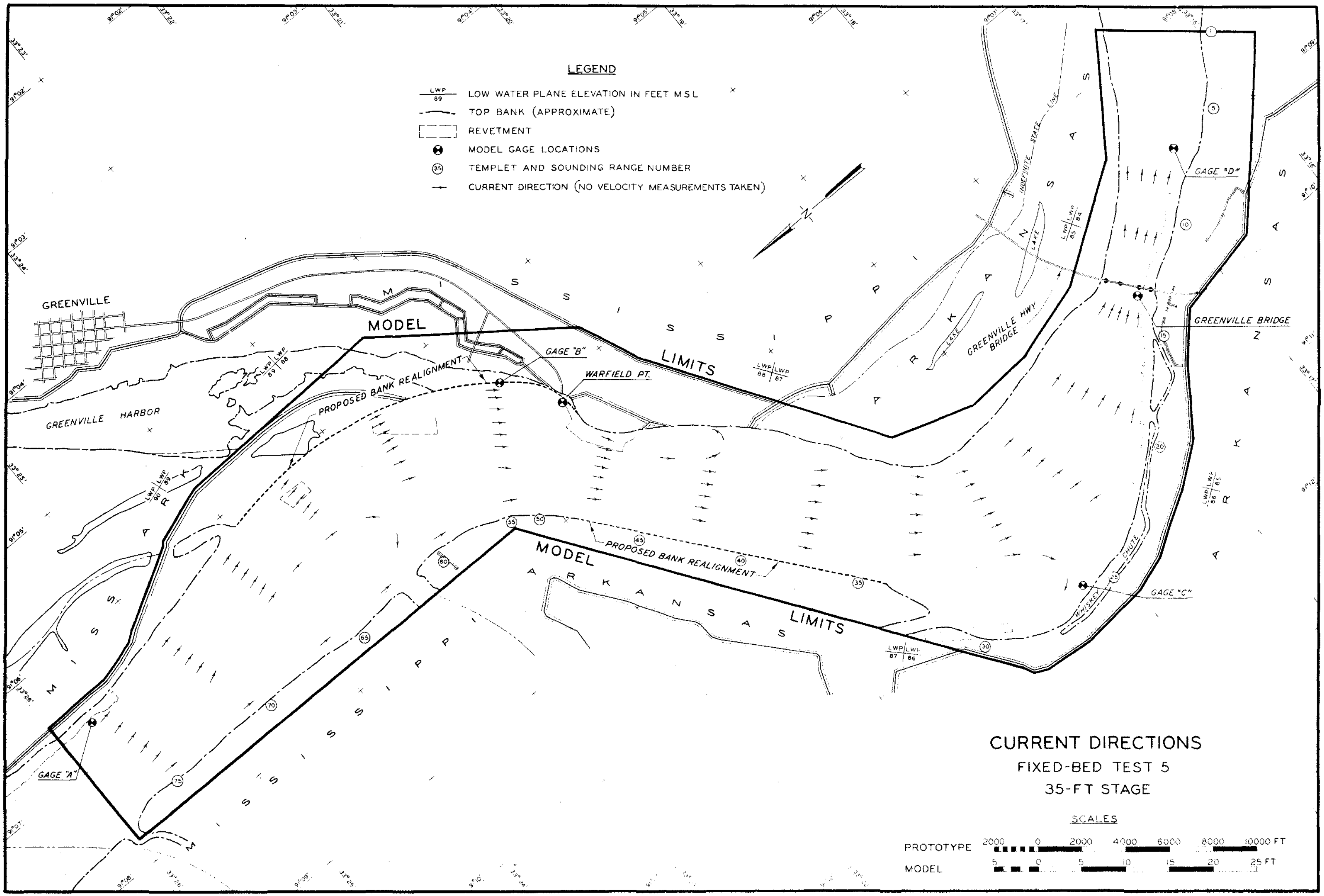
CURRENT DIRECTIONS AND VELOCITIES

FIXED-BED TEST 4

35-FT STAGE

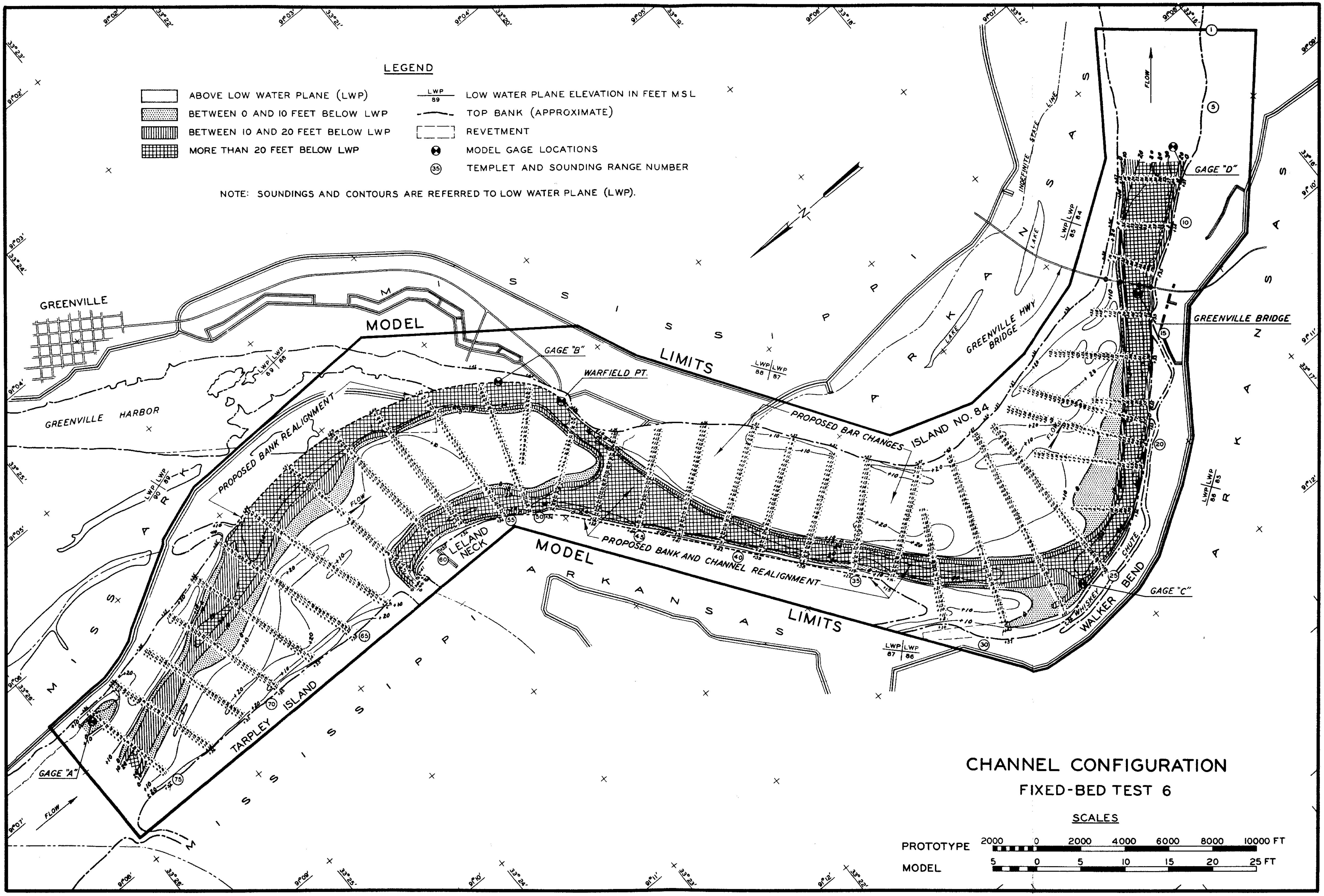


CHANNEL CONFIGURATION
FIXED-BED TEST 5

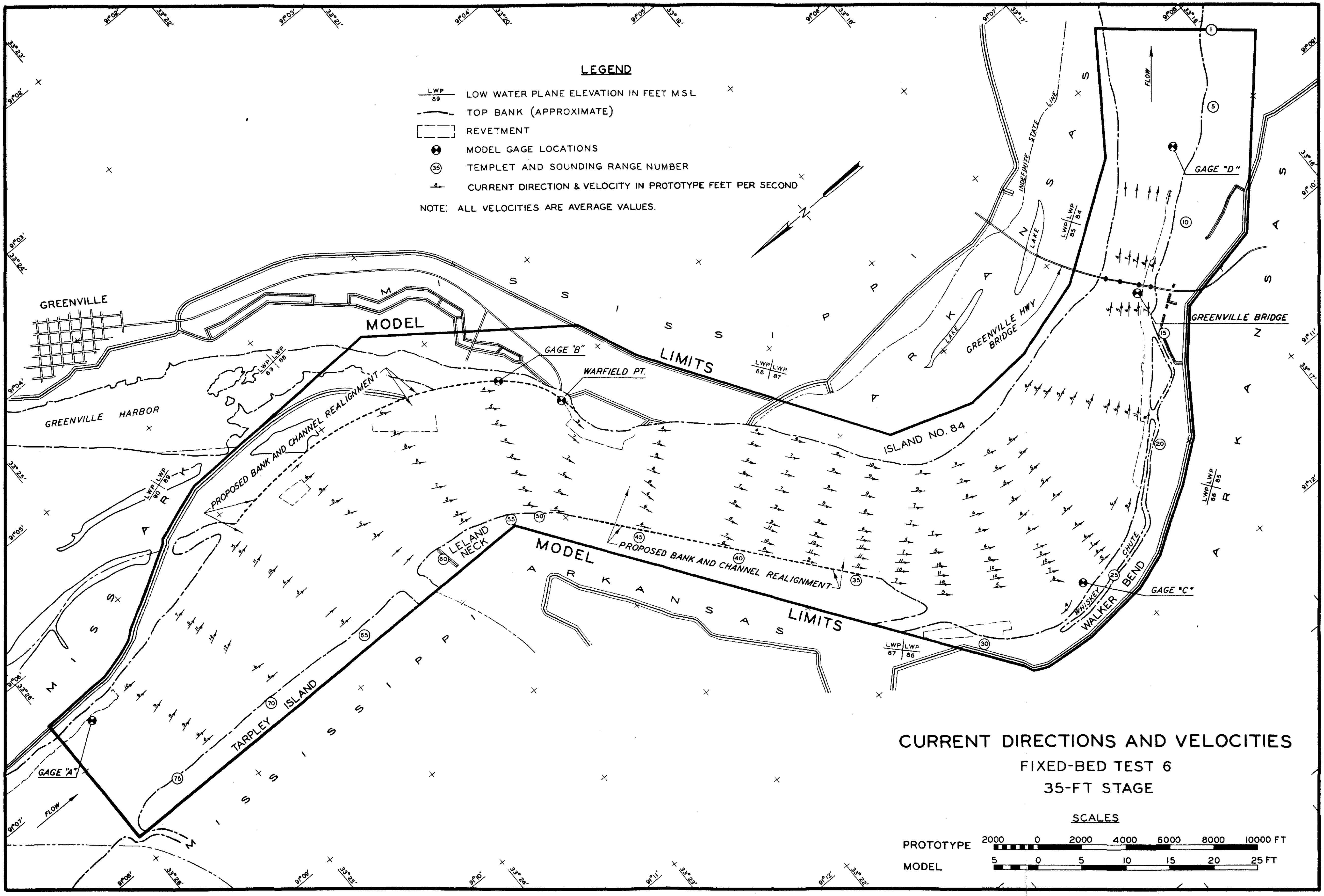


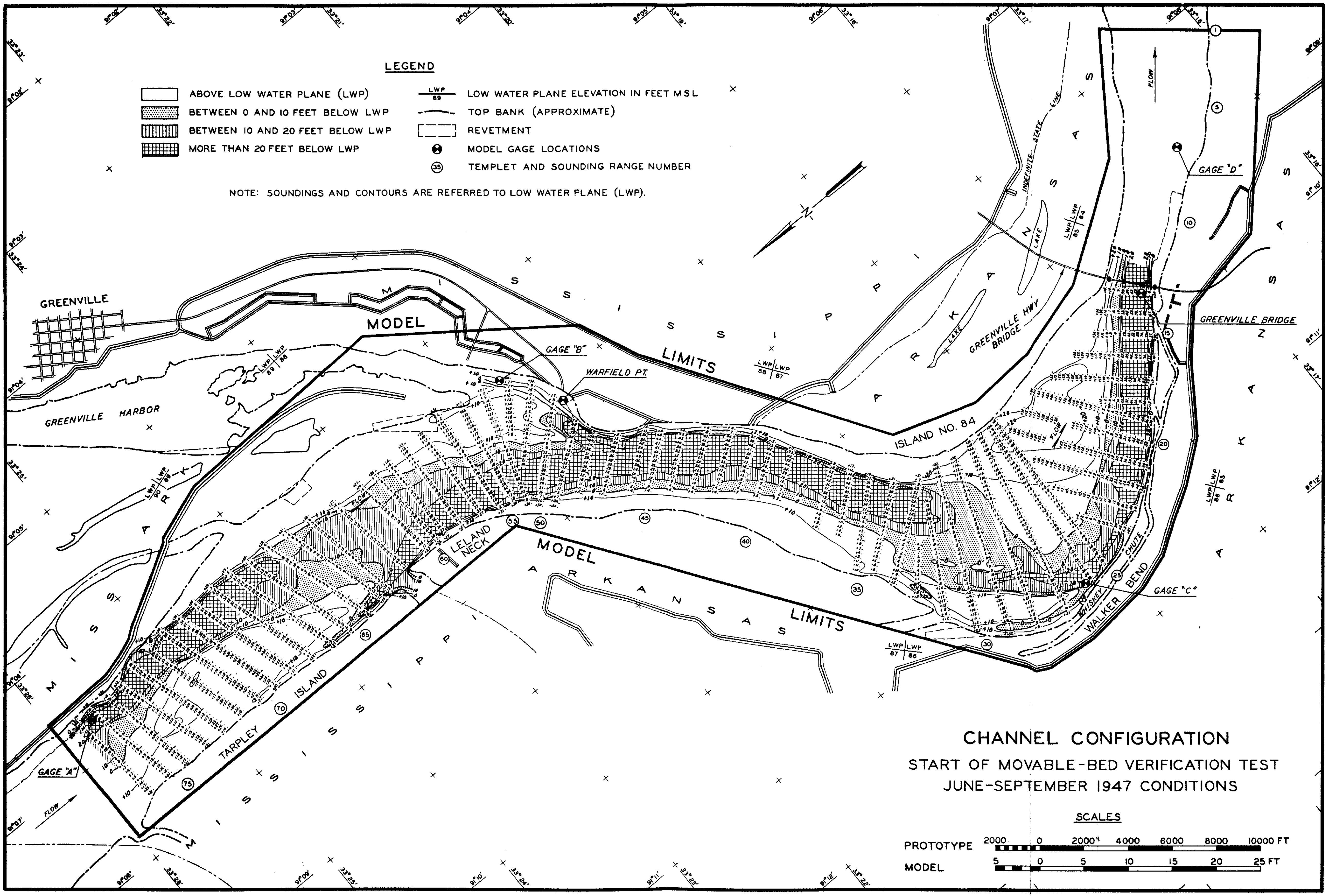
CURRENT DIRECTIONS
FIXED-BED TEST 5
35-FT STAGE

PLATE 15

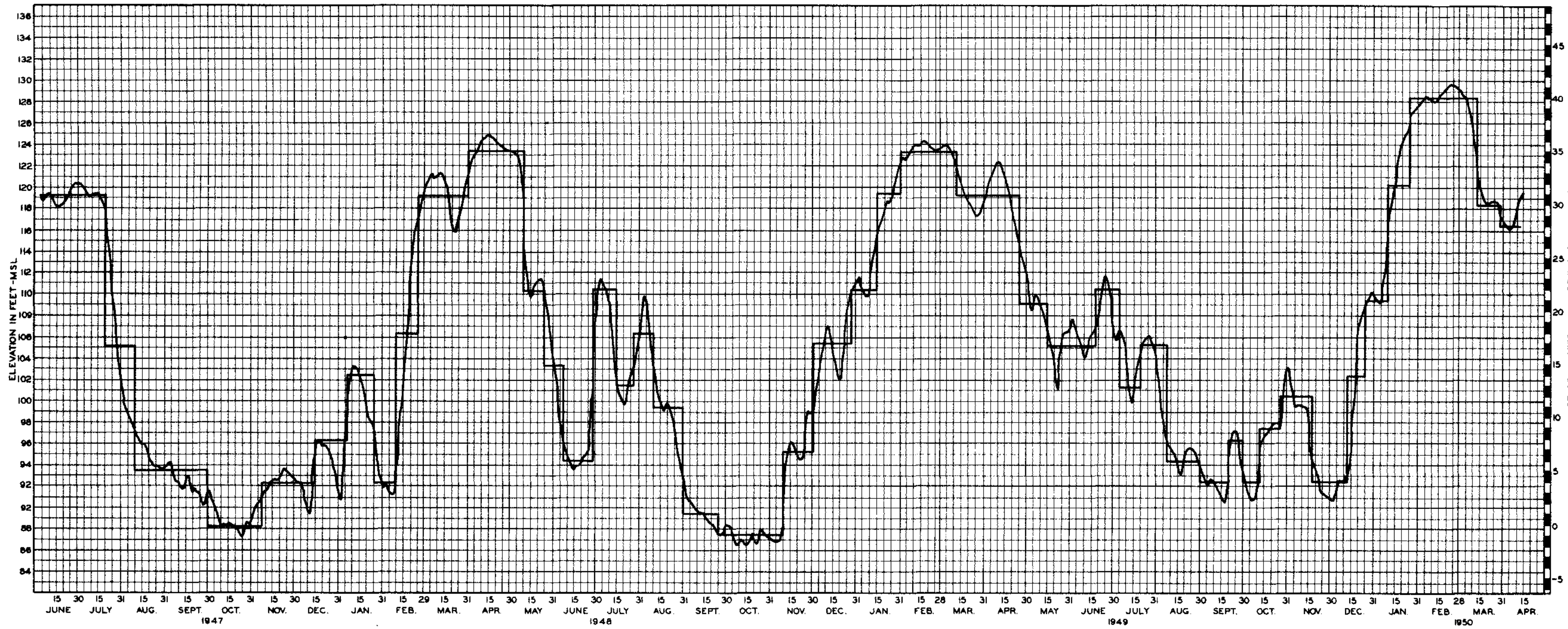


CHANNEL CONFIGURATION
FIXED-BED TEST 6
SCALES


LEGEND
LWP 89 LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
35 TEMPLET AND SOUNDING RANGE NUMBER
CURRENT DIRECTION & VELOCITY IN PROTOTYPE FEET PER SECOND
NOTE: ALL VELOCITIES ARE AVERAGE VALUES.
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "B"
WARFIELD PT.
GAGE "D"
GREENVILLE BRIDGE
GREENVILLE HWY BRIDGE
INDEFINITE STATE LINE
LAKE
ISLAND NO. 84
PROPOSED BANK AND CHANNEL REALIGNMENT
LELAND NECK
GAGE "C"
WHISKEY CHUTE
WALKER BEND
TARPLEY ISLAND
GAGE "A"
FLOW
MISSISSIPPI
ARKANSAS
CURRENT DIRECTIONS AND VELOCITIES
FIXED-BED TEST 6
35-FT STAGE
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT



CHANNEL CONFIGURATION
START OF MOVABLE-BED VERIFICATION TEST
JUNE-SEPTEMBER 1947 CONDITIONS



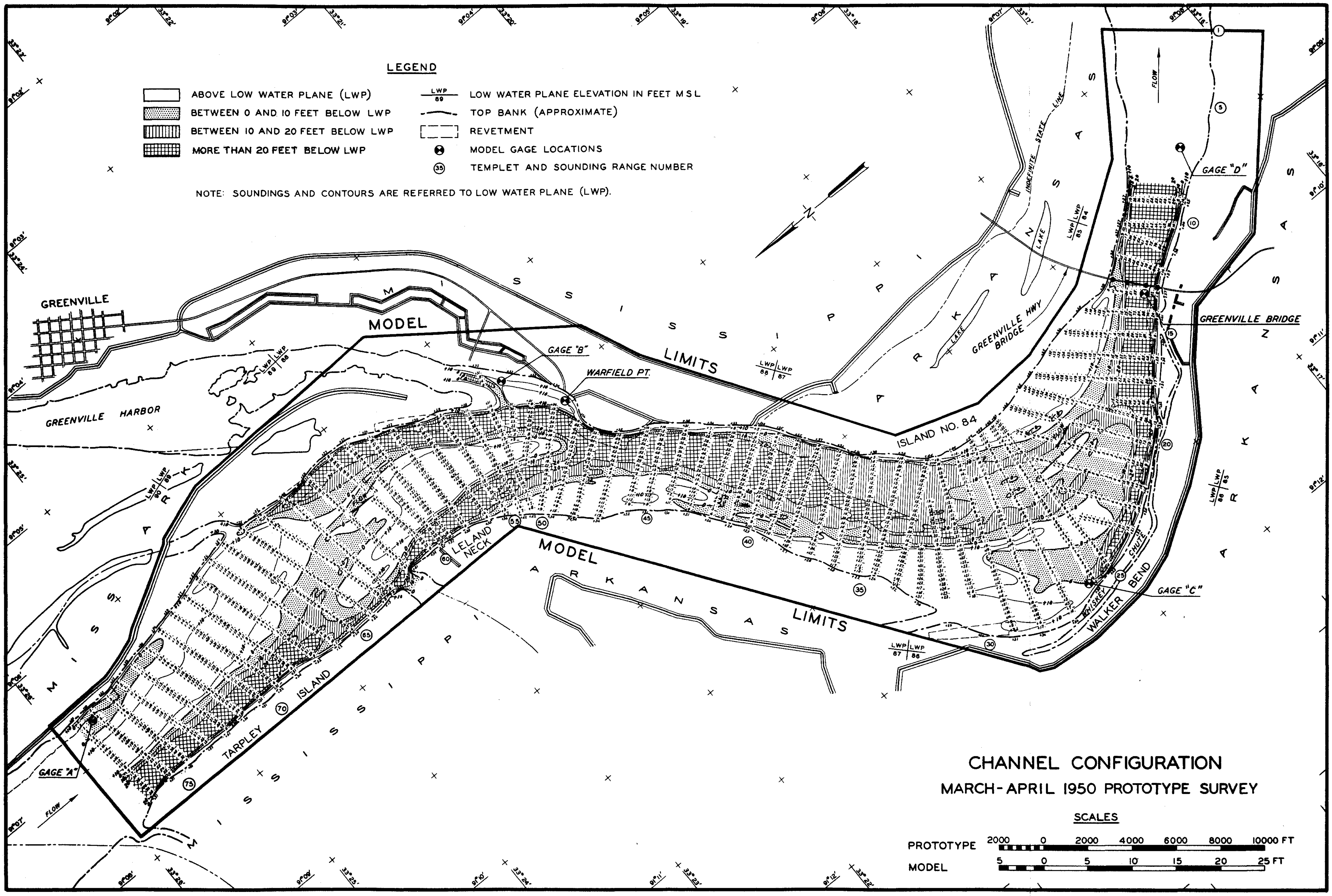
LEGEND

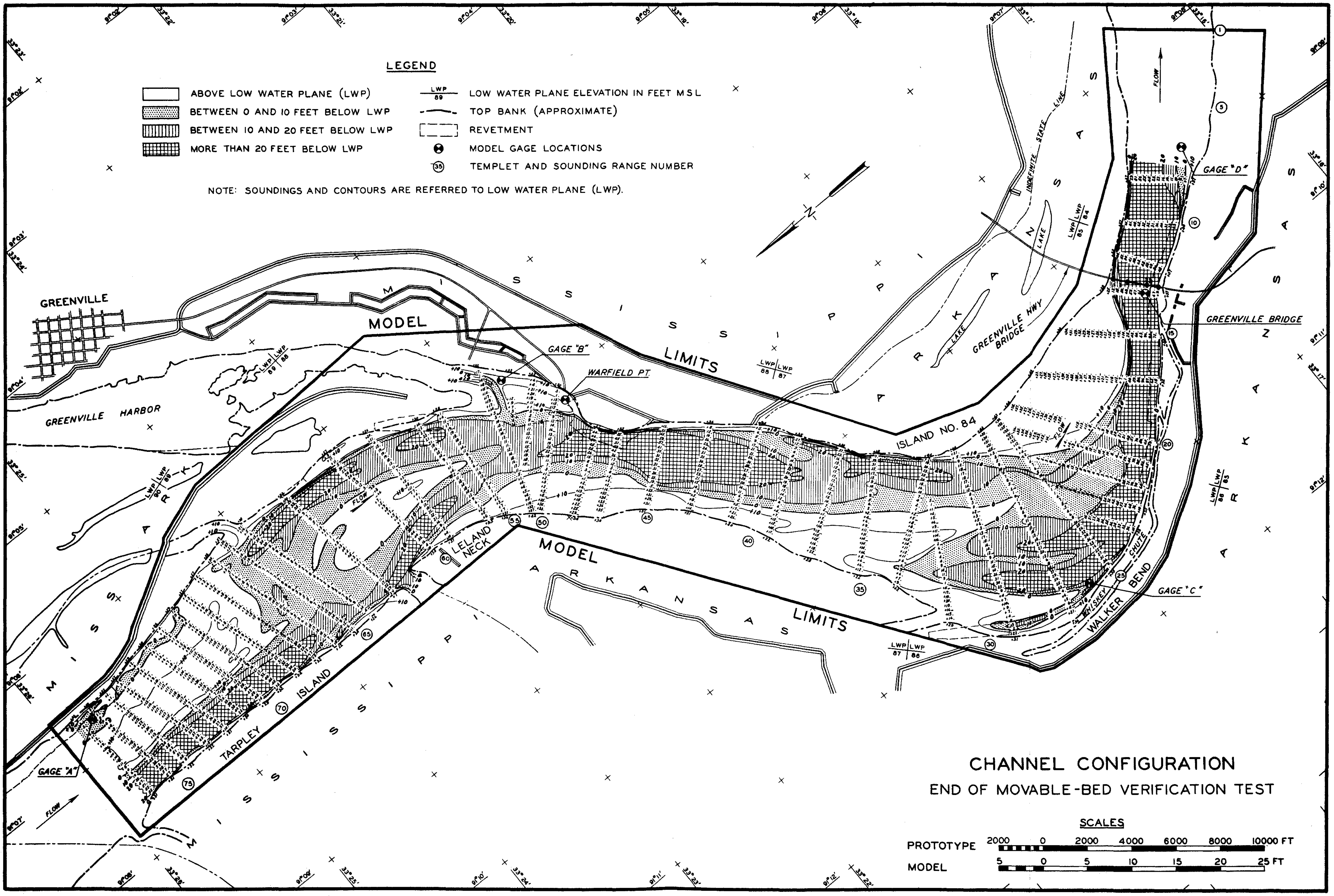
1947-1950 PROTOTYPE HYDROGRAPH

1947-1950 MODEL HYDROGRAPH

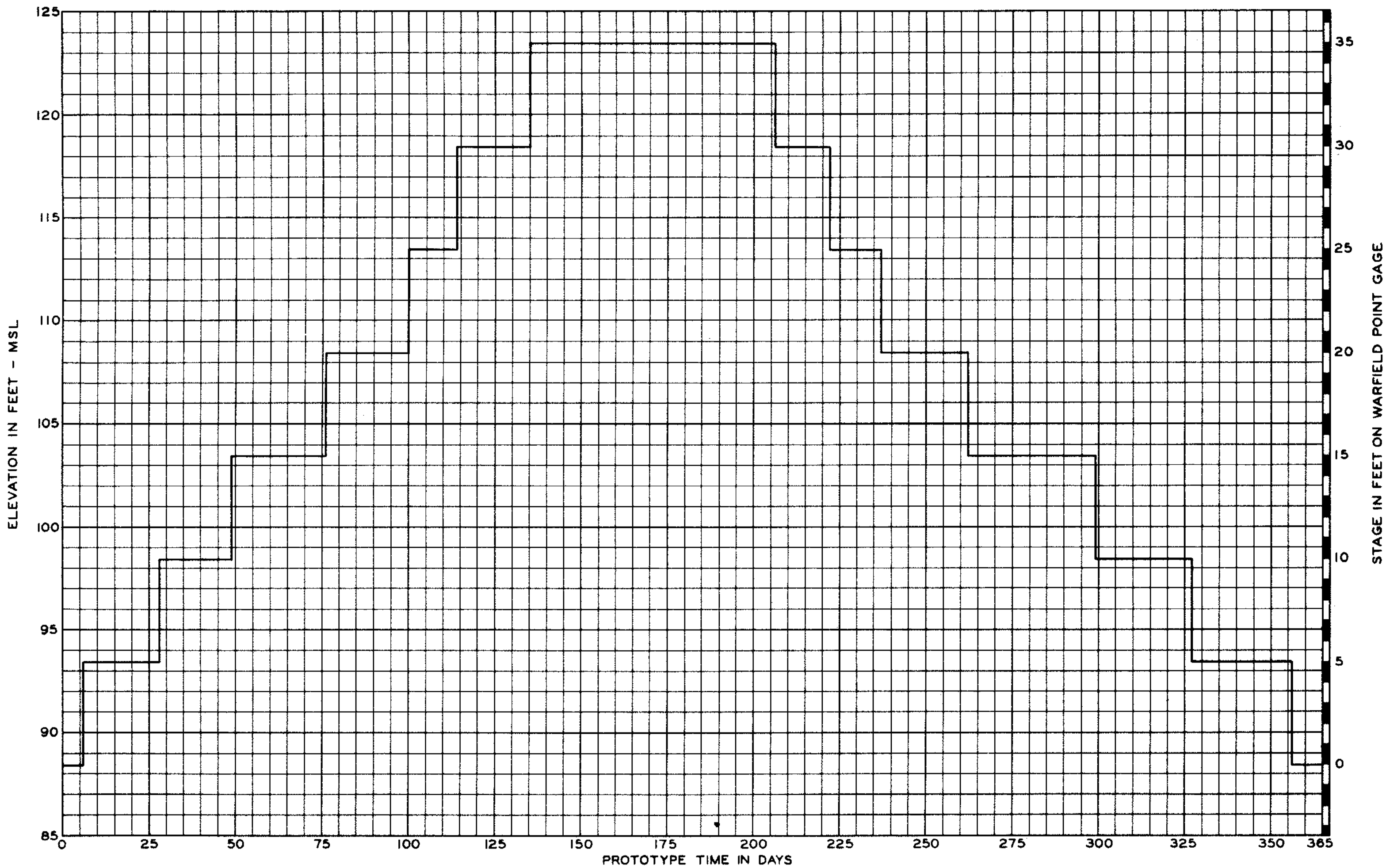
MODEL HYDROGRAPH

MOVABLE-BED VERIFICATION TEST


LEGEND
ABOVE LOW WATER PLANE (LWP)
BETWEEN 0 AND 10 FEET BELOW LWP
BETWEEN 10 AND 20 FEET BELOW LWP
MORE THAN 20 FEET BELOW LWP
LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
TEMPLET AND SOUNDING RANGE NUMBER
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO LOW WATER PLANE (LWP).
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "B"
WARFIELD PT.
ISLAND NO. 84
GAGE "D"
GREENVILLE BRIDGE
GREENVILLE HWY BRIDGE
LAKE
INDEFINITE STATE LINE
LELAND NECK
TARPLEY ISLAND
GAGE "A"
GAGE "C"
WHISKEY CHUTE
WALKER BEND
FLOW
MISSISSIPPI
ARKANSAS
CHANNEL CONFIGURATION
MARCH-APRIL 1950 PROTOTYPE SURVEY
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT

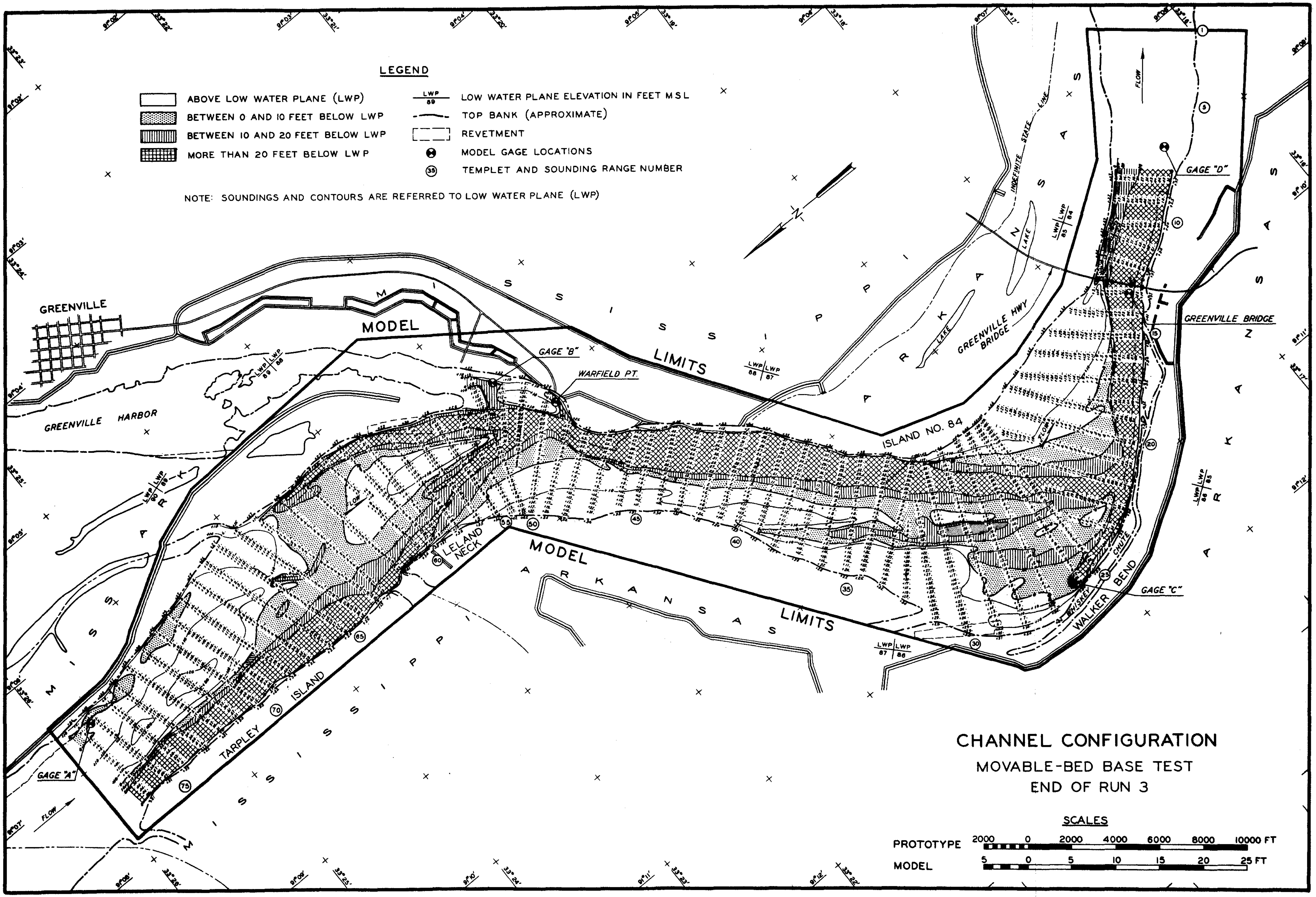


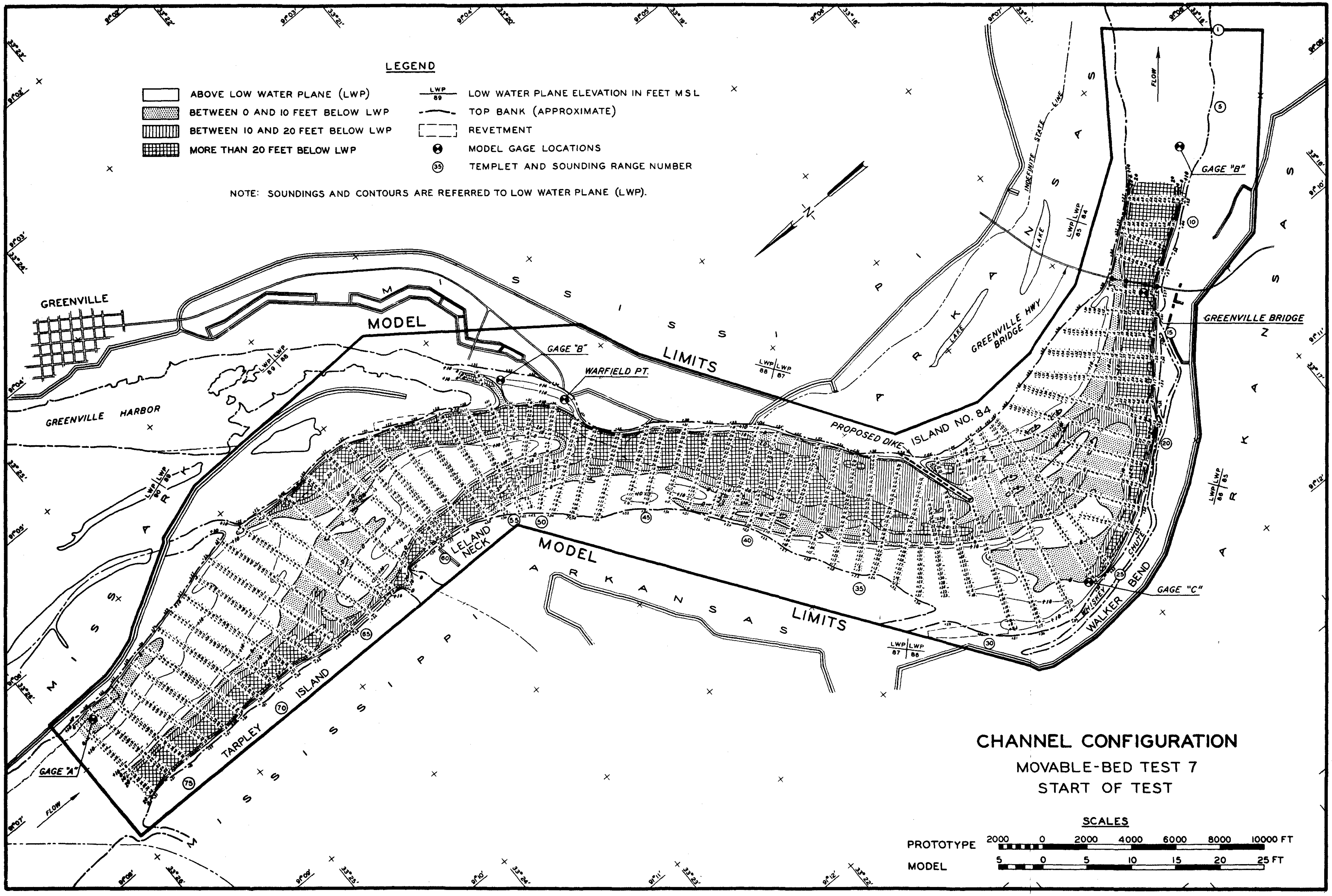
CHANNEL CONFIGURATION
END OF MOVABLE-BED VERIFICATION TEST



NOTE: TIME SCALE: 15 MODEL HOURS EQUAL
ONE PROTOTYPE YEAR.

MODEL HYDROGRAPH
MOVABLE-BED TESTS
AVERAGE OF 1940-49 PROTOTYPE STAGES

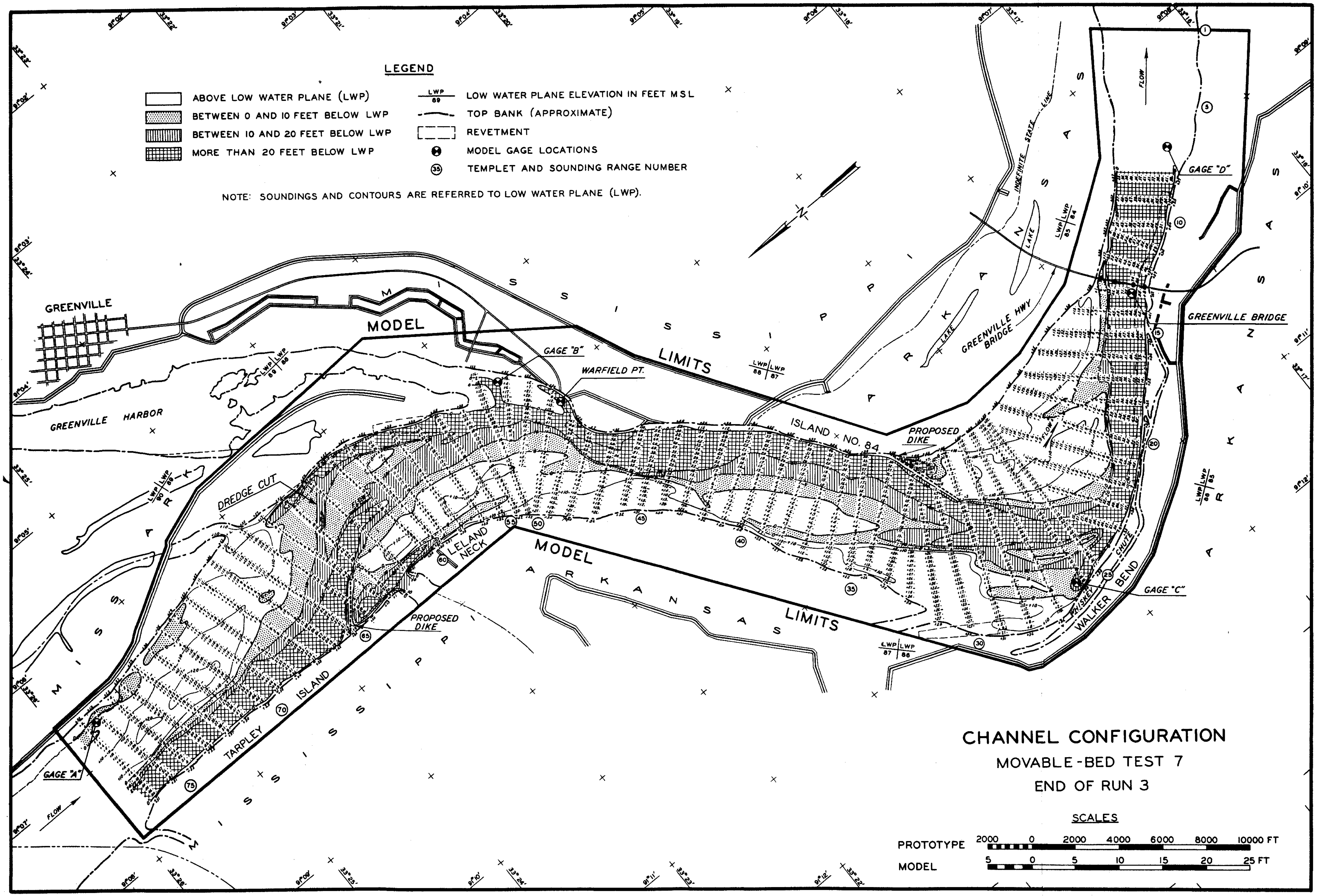

LEGEND
ABOVE LOW WATER PLANE (LWP)
BETWEEN 0 AND 10 FEET BELOW LWP
BETWEEN 10 AND 20 FEET BELOW LWP
MORE THAN 20 FEET BELOW LWP
LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
TEMPLET AND SOUNDING RANGE NUMBER
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO LOW WATER PLANE (LWP)
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "A"
GAGE "B"
GAGE "C"
GAGE "D"
WARFIELD PT.
ISLAND NO. 84
LELAND NECK
TARPLEY ISLAND
WHISKEY CHUTE
WALKER BEND
GREENVILLE HWY BRIDGE
GREENVILLE BRIDGE
INDEFINITE STATE LINE
LAKE
FLOW
MISSISSIPPI
ARKANSAS
CHANNEL CONFIGURATION
MOVABLE-BED BASE TEST
END OF RUN 3
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT

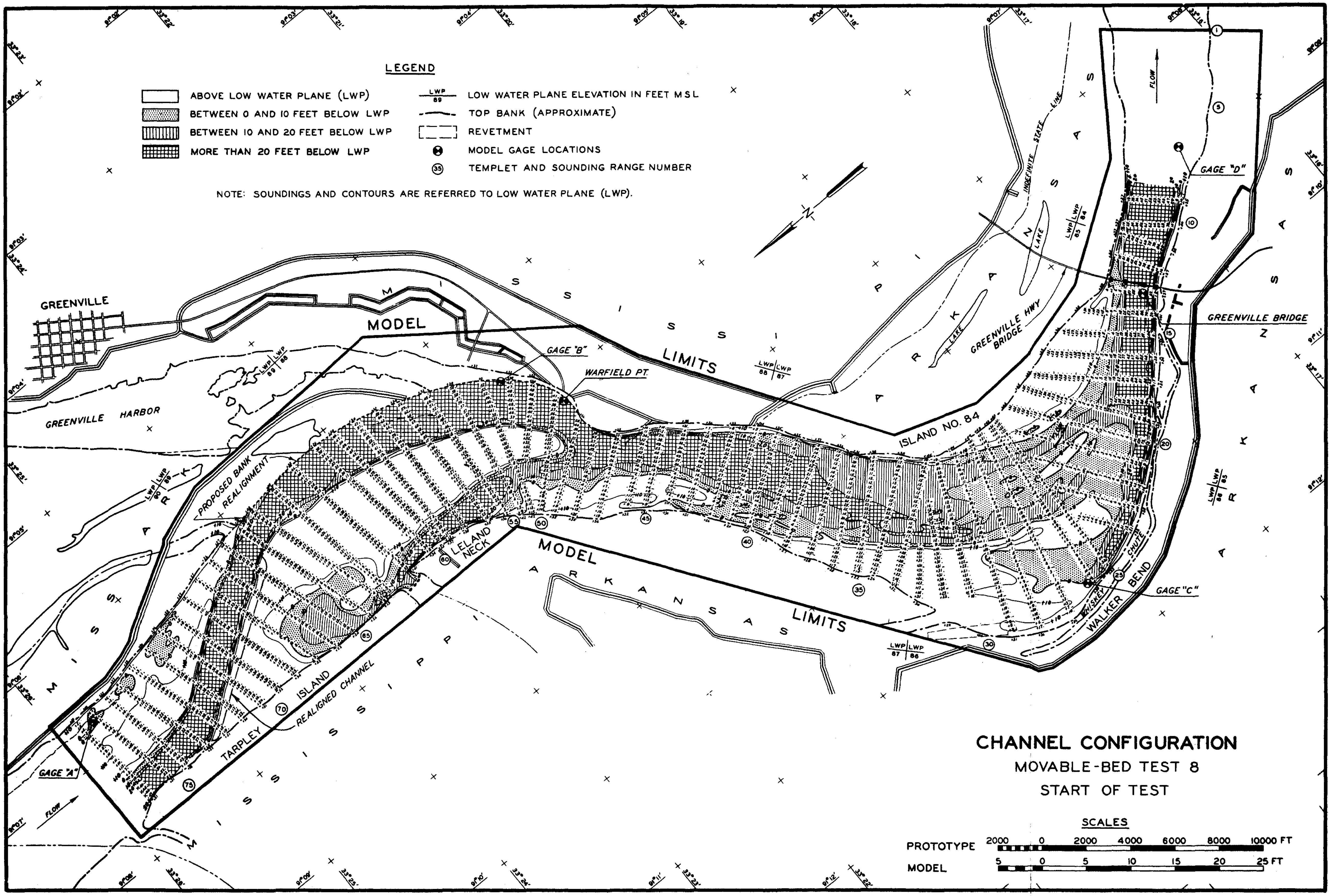


CHANNEL CONFIGURATION

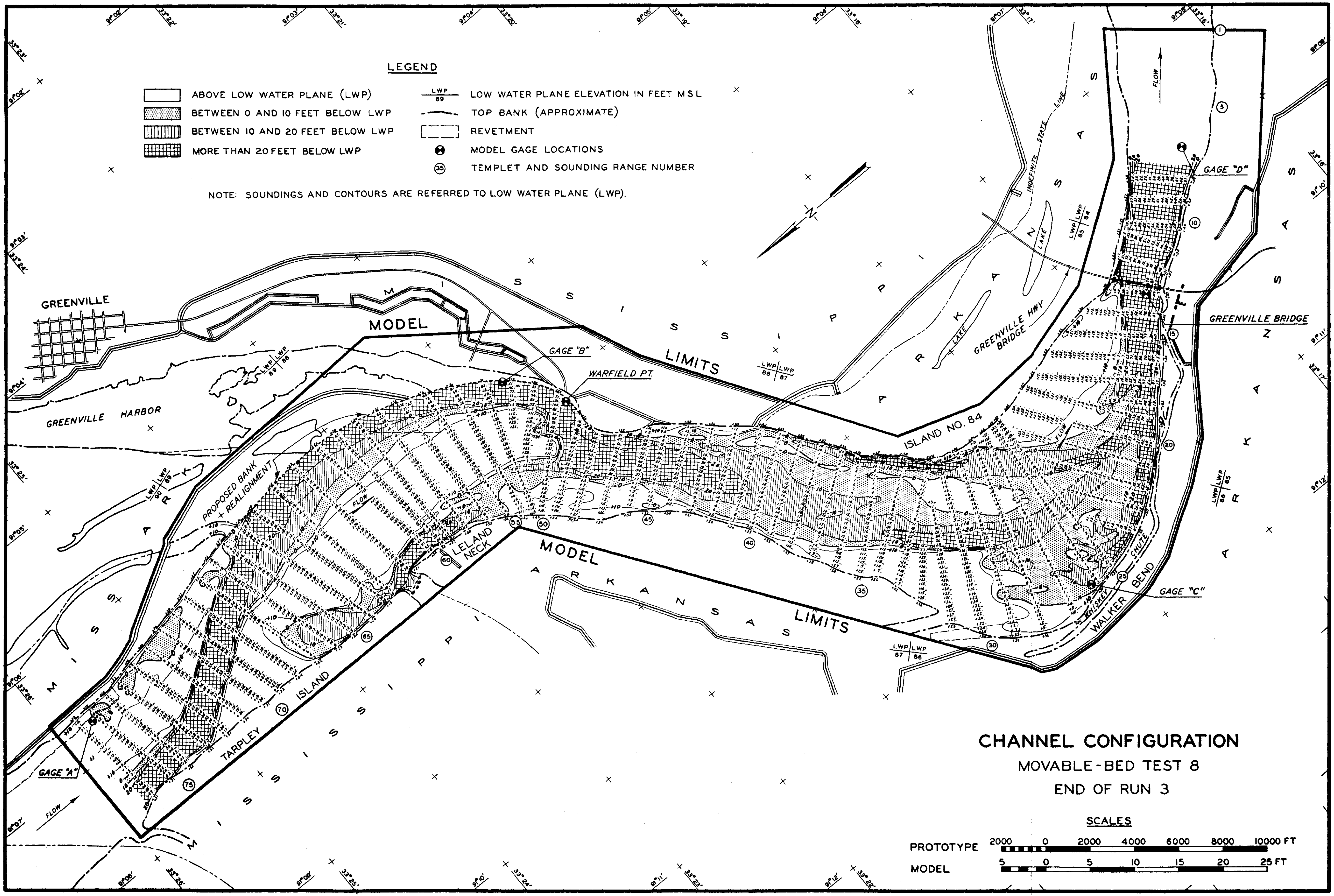
MOVABLE-BED TEST 7

START OF TEST

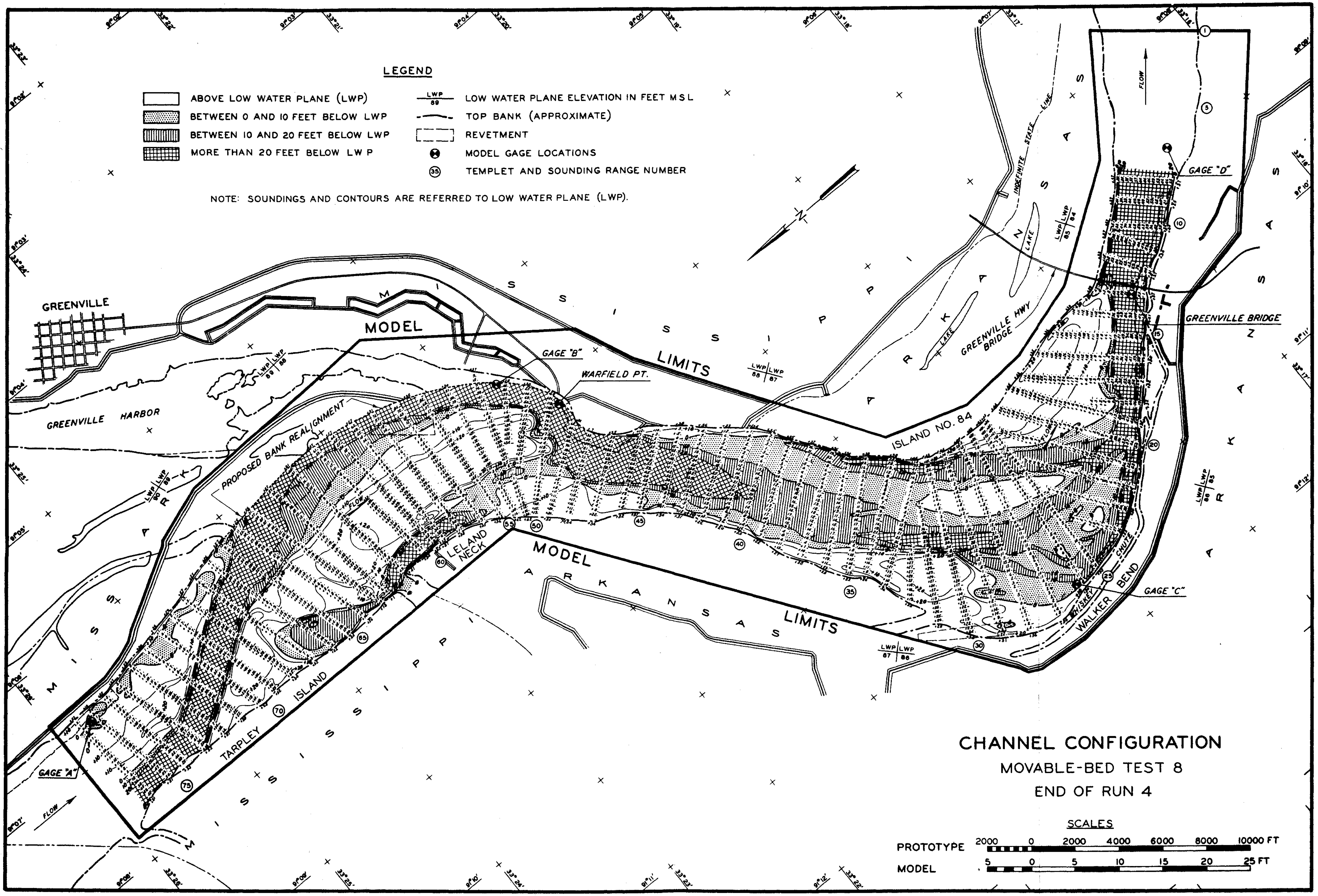

LEGEND
ABOVE LOW WATER PLANE (LWP)
BETWEEN 0 AND 10 FEET BELOW LWP
BETWEEN 10 AND 20 FEET BELOW LWP
MORE THAN 20 FEET BELOW LWP
LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
TEMPLET AND SOUNDING RANGE NUMBER
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO LOW WATER PLANE (LWP).
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "A"
GAGE "B"
GAGE "C"
GAGE "D"
WARFIELD PT.
ISLAND NO. 84
PROPOSED DIKE
DREDGE CUT
LELAND NECK
TARPLEY ISLAND
WALKER BEND
WHISKEY CHUTE
GREENVILLE BRIDGE
GREENVILLE HWY BRIDGE
INDEFINITE STATE LINE
LAKE
FLOW
MISSISSIPPI
ARKANSAS
CHANNEL CONFIGURATION
MOVABLE-BED TEST 7
END OF RUN 3
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT



CHANNEL CONFIGURATION
MOVABLE-BED TEST 8
START OF TEST



CHANNEL CONFIGURATION
MOVABLE-BED TEST 8
END OF RUN 3


LEGEND
ABOVE LOW WATER PLANE (LWP)
BETWEEN 0 AND 10 FEET BELOW LWP
BETWEEN 10 AND 20 FEET BELOW LWP
MORE THAN 20 FEET BELOW LWP
LOW WATER PLANE ELEVATION IN FEET MSL
TOP BANK (APPROXIMATE)
REVETMENT
MODEL GAGE LOCATIONS
TEMPLET AND SOUNDING RANGE NUMBER
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO LOW WATER PLANE (LWP).
GREENVILLE
GREENVILLE HARBOR
MODEL LIMITS
GAGE "A"
GAGE "B"
GAGE "C"
GAGE "D"
WARFIELD PT.
PROPOSED BANK REALIGNMENT
LELAND NECK
TARPLEY ISLAND
ISLAND NO. 84
GREENVILLE HWY BRIDGE
GREENVILLE BRIDGE
WALKER BEND
WISKEY CHUTE
INDEFINITE STATE LINE
LAKE
FLOW
MISSISSIPPI
ARKANSAS
CHANNEL CONFIGURATION
MOVABLE-BED TEST 8
END OF RUN 4
SCALES
PROTOTYPE 2000 0 2000 4000 6000 8000 10000 FT
MODEL 5 0 5 10 15 20 25 FT